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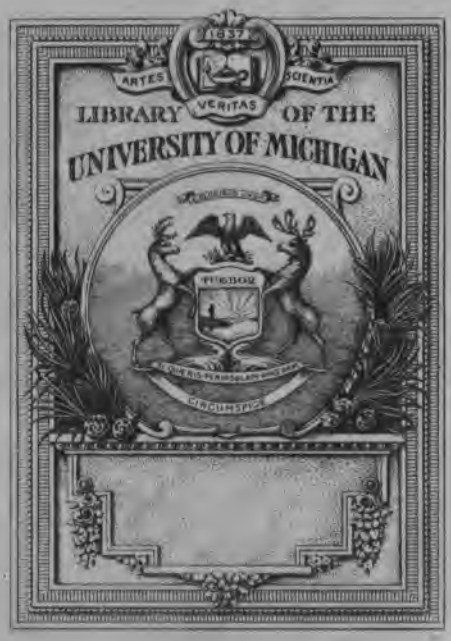
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GEOLOGICAL SURVEY OF THE STATE OF NEW YORK.

(GEOLOGICAL MAP.)

REPORT ON THE GEOLOGY OF CLINTON COUNTY.

JAMES HALL,
State Geologist.

H. P. CUSHING,
Assistant.

1895.

JAMES HALL, *State Geologist,*

SIR:—Herewith I submit a report upon geologic investigations prosecuted by me in Clinton county.

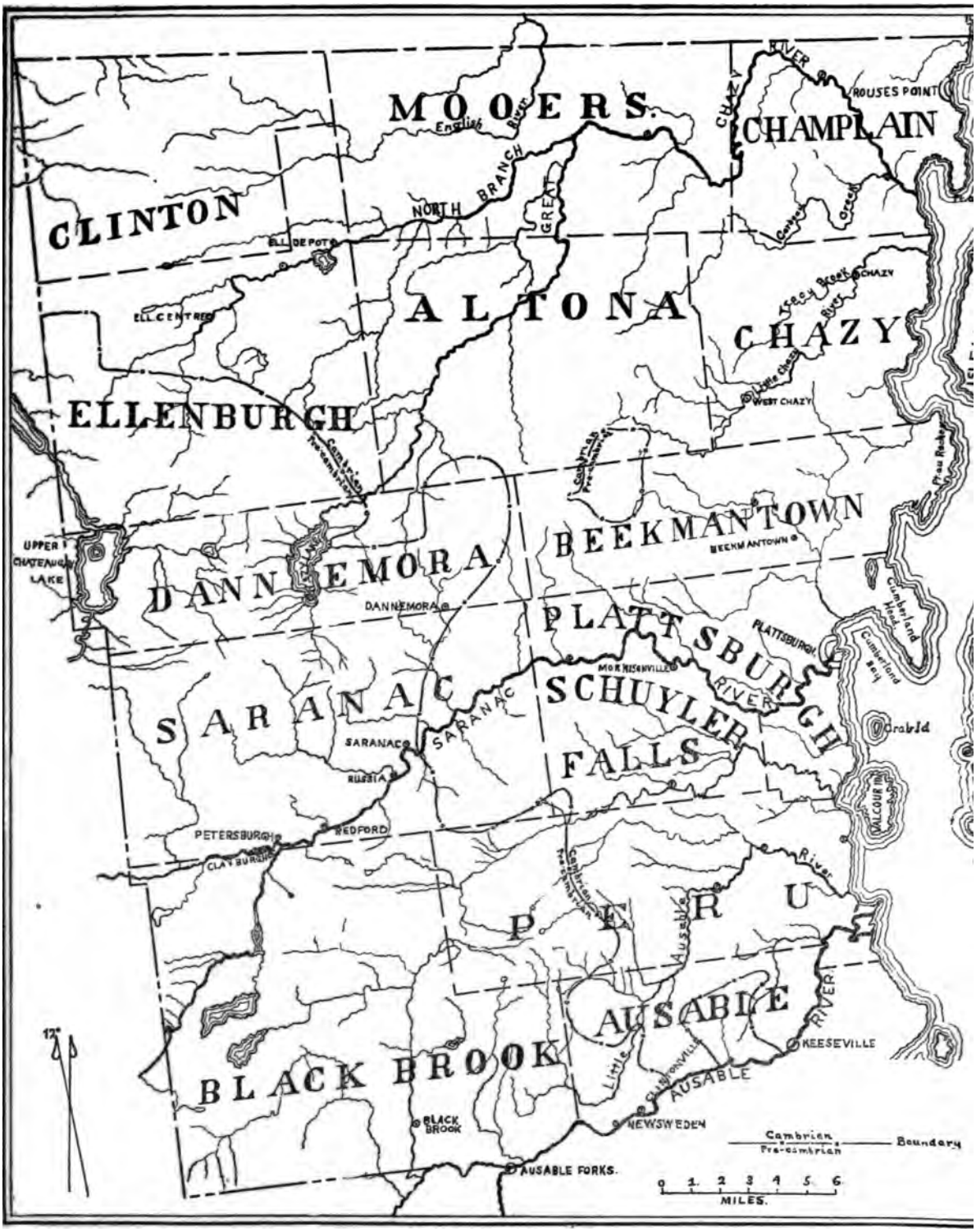
Respectfully yours,

H. P. CUSHING.

WESTERN RESERVE UNIVERSITY, *May* 15, 1896.

UNIV. OF MICH.

PLATE I



OF CLINTON COUNTY; SHOWING THE BOUNDARY BETWEEN THE CAMBRIAN AND PRECAMBRIAN FO

Report on the Geology of Clinton County.

By H. P. Cushing.

Contents. *Introduction*, p. 503. *Topography*, p. 504. *General Geologic Relations*, p. 506: I. Gneissic Series, p. 506; II. Limestone Series, p. 508; III. Gabbro Series, p. 508; IV. Palæozoic Series, p. 510; Potsdam Sandstone, p. 510; Calciferous Sandrock, p. 512; Chazy Limestone, p. 513; Black River Limestone, p. 514; Trenton Limestone, p. 514; Utica Slate, p. 515; V. Dike Series, p. 515; VI. Pleistocene Deposits, p. 527. *Metamorphism of the Pre-Cambrian Rocks*, p. 529. *Post-Ordovician Disturbances*, p. 530; *Township Geology*, p. 531: Clinton Township, p. 532; Mooers Township, p. 532; Ellenburgh Township, p. 533; Dannemora Township, p. 535; Saranac Township, p. 538; Black Brook Township, p. 541; Ausable Township, p. 545; Peru Township, p. 549; Schuyler Falls Township, p. 552; Plattsburgh Township, p. 553; Beekmantown Township, p. 559; Altona Township, p. 562; Chazy Township, p. 562; Champlain Township, p. 571.

The field work the general results of which are presented in this report, was done during the field seasons of 1893–'94–'95, about four weeks during each being devoted to the work. On the last two occasions, Mr. M. L. McBride, of Cleveland, at his own expense, accompanied the writer as assistant and rendered valuable service. During 1895, a week was spent with Messrs. Gilbert van Ingen and T. G. White, of Columbia College, in inspecting the best exposures of the Ordovician limestones in the county, and Mr. van Ingen's palaeontologic ability was of great service in making clear some perplexing points in the stratigraphy.

The entire county has been traversed and mapped, but only in a general way, the desideratum being the acquisition of a good general knowledge of the district before attempting the detailed work which will be necessary for the proper elucidation of the perplexing problems which have arisen. Furthermore, no good, or even fair maps exist of the greater part of the county, so that, until such are available, it is useless to attempt closer work. A beginning has, however, been made in the detailed mapping of the palaeozoic rocks along lake Champlain, which is necessary in order to fully bring out the structural features, and it is the present expectation to continue this as opportunity offers.

Since the report of Professor Emmons, over fifty years ago, practically nothing has been published on the geology of the county except the beautiful bits of mapping and sectioning done by President Brainard and

Professor Seely. In addition to what they have published, President Brainard writes me that they have mapped the lake shore southward from Plattsburgh. It is hoped that this map will soon be published.*

TOPOGRAPHY.

Clinton is the extreme northeast county of the state of New York, lake Champlain forming the eastern, and the Dominion of Canada the northern boundary. Its area is approximately 1,093 square miles. It lies entirely within the St. Lawrence drainage basin, sloping for the most part to the northeast. Close to the Franklin county line, and nearly parallel with it, ranging northward from Upper Chateaugay lake is a pronounced watershed, west of which the drainage is into the Chateaugay river and thence northward, while east of it the streams flow to the northeast and east. Of the larger streams emerging from the northern Adirondacks, the Saranac and Great Chazy rivers flow clear across the county, while the Ausable forms part of its southern boundary.

Topographically the county is separable into three well marked divisions:

1. A hilly or somewhat mountainous southwestern portion, occupying something over one-third of the county, constituting a part of the northeastern Adirondacks and characterized by their conformation; in other words composed of massive ridges trending northeast and southwest, with intervening steep-sided valleys of very variable width. Occasionally the ridges trend east and west. They commonly have a rather gentle slope on the north side, which is deeply drift-covered and heavily timbered, the rocks seldom protruding above the surface; while on the south the slopes are steeper and often precipitous, exhibiting frequent vertical cliffs of considerable height. The highest elevations in the county are Lyon mountain, 3,809 feet, and Catamount mountain, 3,168 feet. The valleys are for the most part heavily drift-filled, with rock exposures only along the larger streams. They sometimes expand into quite wide parks and are not infrequently occupied by lakes, of which Chazy and Upper Chateaugay lakes in Dannemora, and Silver lake in Black Brook, are the most noteworthy.

2. A high-level plain, beneath which the knobs of the older rocks are submerged, and which extends into embayments between their outlying ridges. It has a maximum elevation of about 1,500 feet along its boundary

* Since the above was written the map and description have appeared. See Bulletin American Museum Natural History, Vol. VIII., 1896, pp. 305-310. The results agree with those obtained by the writer.

with the hilly tract, and slopes thence gently northward to the brink of the St. Lawrence valley. The surface rock throughout in this county is the Potsdam sandstone which lies nearly horizontal, having but a slight northerly dip, so that its descent is not greatly in excess of the average surface fall. The covering of glacial material is widespread but mostly confined to the depressions, and the numerous, often large, marshy tracts testify to its irregularity.

The streams draining northward across the plain have for the most part not channelled it very deeply since the close of the glacial period, on account of the horizontal attitude of the rocks and their resistant character. During the late Tertiary, the plain was much dissected by the drainage, but even then the valleys were relatively narrow, the present summits of the plain consisting of comparatively wide table lands of sandstone instead of narrow ridges and mounds. The new maps cover a portion of this plain in Mooers and Altona and indicate that these summits represent portions of an earlier base level, now tilted to the north.

3. A low strip along the lake, ranging from the lake level to an altitude of 300 feet on its western border, and increasing in breadth going north. From the 300 foot to the 500 foot level, the rise is quite abrupt, especially in Chazy township, and the topography strongly suggests a fault, raising the Potsdam on the west some hundreds of feet above that on the east, and marking the boundary between the low strip and the high plain. Further to the south, the heavy Pleistocene deposits largely obliterate this contrast. This low strip is greatly dissected by faults, and to their presence its minor topographic features are largely due. The fault lines are occupied by marshes or small streams, while between them ledges of rock project at all angles in a seemingly haphazard and at first, quite bewildering fashion.

Throughout this low strip the main streams quite generally follow their pre-glacial channels. The Saranac and Great Chazy rivers have channelled out considerable valleys in the drift and are now widening them. The Great Chazy river is in its pre-glacial channel throughout the low strip, exposing nothing but drift in its banks. At Mooers village it leaves the old channel for a short distance, and thence up-stream this frequently happens, but this channel belongs topographically to the high plain. The Saranac is out of its old course at the pulp mill, two miles above Plattsburgh, thence keeps to its old valley till Cadyville is reached. Here a considerable gorge has been cut in the Potsdam, but this is beyond the confines of the low strip.

The smaller streams, the Little Chazy, Salmon and Little Ausable rivers are wholly or mainly in post-glacial channels, and give little clue to the minor pre-glacial drainage. Such part of the county as is most suitable for agricultural purposes is mainly confined to this strip, and on it are many fine farms.

GENERAL GEOLOGIC RELATIONS.

Professor J. F. Kemp has recently published a resumé of the schemes of classification which have been proposed for the rocks of the Adirondack region, to which he has added a tentative one of his own.*

This, which comprises:

(I.) A basal gneissic series.
(II.) A series of schists and gneisses with crystalline limestone.
(III.) Igneous rocks of the gabbro type.
(IV.) Palæozoic sediments, lying unconformably on the first three.
(V.) Igneous rocks found as dikes cutting all the foregoing, and
(VI.) Pleistocene deposits;

will be followed in this report, emphasis being laid on the fact that it is tentative, and probably simpler than the one finally adopted is likely to be. The writer has elsewhere given reasons for holding that this scheme must be expanded by the insertion of another period of dike formation between (III.) and (IV.).†

As exposed in Clinton county these subdivisions may be epitomized as follows:

Series I. The oldest rocks visible so far as known belong to a great series of gneisses and are well shown in all the western tier of townships except Clinton, and in Peru and Ausable. In their typical development they are easily recognized. They present well-marked varieties, as below, all of which seem to grade into one another.

1. Gneisses, commonly of red color, but also grey, brown, and other shades, composed mainly of microperthitic orthoclase and quartz. Occasionally these are the only constituents, when the gneissoid structure retreats and a red granite rock results which seems to be merely a phase of the gneiss. There has not yet been found in the county a granite which can be shown to be intrusive in the gneiss, like that described by Smyth in St. Lawrence and Jefferson counties.‡ More commonly one or more of the minerals magnetite,

* J. F. Kemp, Report New York State Geologist for 1893, Vol. I., pp 444-447.
† H. P. Cushing, Transactions New York Academy of Sciences, Vol. XV., pp. 248-252.
‡ C. H. Smyth, Jr., Transactions New York Academy of Sciences, Vol XII., pp 208 to 212.

plagioclase feldspar, microcline, biotite, hornblende and titanite are present in varying amounts, and small apatites and zircons are almost universal. Locally a green augite also appears, but this is not a common occurrence in this county. With the appearance of the more basic minerals the foliation of the rock becomes apparent and increases in prominence as they increase in abundance. Sometimes the quartz retreats and locally may be entirely lacking. An increase in plagioclase frequently accompanies this change, so that the rock grades from a quartz-orthoclase into a plagioclase gneiss, often without making any noticeable difference in the external appearance of the rock.

2. Widely exposed in Black Brook township are gneisses of quite different appearance, and, judging from published descriptions of the Adirondack gneisses, of an unusual type. For the most part they are very finely granular, but alternate with numerous, often broad, coarse, pegmatite-like bands. The fine-grained rock is of a prevailing lavender-grey or lilac-grey tint, showing, when freshly broken, small, brilliant cleavage faces of feldspar. It is quite free from basic minerals, hence foliation is not especially apparent. The coarse rock is not unlike similar coarse bands in the ordinary gneisses, but is more abundant here, alternating regularly with the other. There are also present occasional thin bands of a basic gneiss weathering with a rusty hue.

In thin sections, both the coarse and fine varieties are seen to be made up mainly, and often wholly, of microcline and quartz, the microcline having almost universally a markedly microperthitic habit. Apatite is seldom absent, and often abundant. Plagioclase and microperthitic orthoclase are frequently present, sometimes in considerable quantity, and some slides show small amounts of magnetite, biotite and hornblende, these being more plentiful in the coarse bands.

Closely associated with these gneisses are others which, outwardly, more nearly resemble the ordinary gneiss, and which have plagioclase for their most prominent constituent, together with microcline, orthoclase, quartz, magnetite and ferro-magnesian silicates in varying amounts. By their distribution the impression is created that through them the microcline gneisses grade into the ordinary orthoclase gneisses.

These microcline gneisses are in rather close juxtaposition to an area occupied by the limestone series, and perhaps should be classed with that. The thin bands of rusty basic gneiss interfoliated with them resemble gneisses of that series rather more closely than they do the basic bands in the ordinary gneisses. Aside from that indication the field evidence does not lean strongly in either direction.

3. Interbanded with the other gneisses, dark, basic gneisses occur, ranging from an inch to many yards in thickness, and always parallel to the foliation of the enclosing gneiss. They vary much in grain, but in general are rather coarse, and are distinctly schistose in habit. When studied in thin sections they at once separate themselves into two sharply contrasted varieties, the one having the mineralogy of diorite, the other of gabbro. These gabbroic bands are so precisely like the more basic portions of the gabbro masses shortly to be described, that they should unquestionably be classed with them and will be noted in their proper place. The other, and more common variety is composed of plagioclase and hornblende with smaller, but quite constant amounts of orthoclase, biotite and magnetite. Microcline is sometimes present. Quartz may appear in small quantity, and in some instances is found as inclusions in the plagioclase, and there only. Some of these gneisses also carry much green augite along with the hornblende, producing an intermediate rock between the dioritic gneisses and the gabbros. In one specimen there is, instead of augite, a considerable content of an orthorhombic pyroxene which is regarded as bronzite, the pleochroism and double refraction being much weaker than in the ordinary hypersthenes of the region. Measured extinction angles indicate an andesine ranging toward labradorite as the common feldspar.

As has been stated, the mineralogy of the rock is that of a diorite, or, in some cases, of a gabbro-diorite, and its eruptive origin is regarded as highly probable.

The gneissic series contains the workable deposits of magnetic iron ore.

Series II. The rocks of this series consist of coarsely crystalline limestones associated with certain peculiar gneisses and schists quite unlike any members of Series I., and with other gneisses which closely resemble those of that series. But one belt occupied by these rocks exists in Clinton county, so far as known, and in that the exposures are few and meagre so that little knowledge of the group can be obtained here, and the reader is referred to Professor Kemp's descriptions of the numerous better exposures in Essex county.* The Clinton county exposures are in Black Brook township and will be described under the geology of that area.

Series III. This series is constituted of rocks of the gabbro family, which are unquestionably of igneous origin and were intruded into the members of the first two series. The main development of the rocks of this

* J. F. Kemp. Bulletin Geological Society of America, Vol. VI., pp. 241-262; and Annual Report New York State Geologist for 1893, Vol I., p. 444.

group in the Adirondacks, is in Essex county, where they have a greater areal extent than all the other rocks combined, but they pass beyond the borders of that county on all sides. Three outlying areas of this group occur in Clinton county, none of which has been heretofore recognized as belonging to it. The first of these is in Ausable township, extending north and west of Keeseville, and is the direct prolongation northeastward of a great gabbro ridge which comes up to Keeseville from the southwest. The second forms Rand's hill in Beekmantown and Altona townships, is twenty miles north of the last, and interesting as carrying the known Adirondack exposures by that distance nearer to the Canadian; further connecting links, if any, being concealed by the covering of the later rocks beneath which they pass. The third area forms the Catamount mountain ridge in southwestern Black Brook, and Professor Kemp's work during the past season indicates that the Whiteface massive, just over the border to the southwest, is a prolongation of the same. The Catamount mountain exposures are difficult of access, and have not been so thoroughly studied on that account; but the rock, while a little abnormal, is unmistakable gabbro.

In their typical development the Adirondack gabbros, like those of eastern Canada, consist almost wholly of plagioclase feldspar, mostly labradorite, but ranging to anorthite, and to this very feldspathic phase Dr. F. D. Adams has applied the name anorthosite. As the peripheries of the masses are approached, ferro-magnesian silicates appear in increasing quantity, and ultimately the gabbros may become very basic, titaniferous magnetite, augite and sometimes hypersthene being present in large quantity, together with garnet, hornblende and biotite, these latter being largely, if not wholly, secondary. With the appearance of these minerals comes almost always a gneissoid structure in the rock.*

Though the Clinton county gabbro areas are of comparatively slight extent, quite typical anorthosite may be collected from each, occurring in close association with basic gabbro. Sometimes the ordinary gabbro contains narrow bands of a quite basic character, of such persistence and with such sharply defined walls that they closely imitate dikes in appearance. It is more especially such bands as these, or larger masses of the same character, that are quite identical with the bands already mentioned as occurring as basic gneisses in the gneiss series, and which are to be regarded as dikes or apophysae of the main gabbro intrusion which penetrated the gneiss from the parent

* For full descriptions of some phases of the gabbros, see F. D. Adams, Neues Jahrbuch für Min., Vol. VIII., pp. 419-497; J. F. Kemp, Bulletin Geological Society of America, Vol. V., pp. 213-224.

body. When not too finely granulated these basic gabbros show a tendency to the assumption of ophitic structure. Such consist of coarse plagioclase and nearly colorless pyroxene, both extraordinarily full of minute inclusions, embedded in a granular matrix, in large part constituted of secondary minerals, garnet, biotite, hornblende and hypersthene with or without quartz. The feldspar and pyroxene were apparently crystallizing at the same time, for, while the feldspar is frequently idiomorphic against the pyroxene, it also frequently includes the latter, while the reverse has not been observed to occur. These varieties commonly show beautiful reaction rims around the magnetites, similar in all respects to those described by Professor Kemp in the Port Henry gabbro.

Series IV. Unconformably overlying the older crystalline rocks is a group of great thickness of nearly unchanged sedimentary rocks of Cambrian and Ordovician age, which hides the older rocks from view over two-thirds of the county. Unfortunately exposures are not always all that could be desired, and in regard to a small part of the group the stratigraphy is not clear. The whole is seriously in need of thorough palæontologic study, which could not fail to furnish results of great interest and value. The group commences at the bottom with the Potsdam sandstone, and terminates with the Utica slate. No criteria have been found, by means of which an older quartzite series can be discriminated from the Potsdam, as urged by N. H. Winchell for northern New York.* The quartzites and quartz schists of the Grenville series of Canada seem wholly or largely lacking in the eastern Adirondacks, though they may occur on the west. Furthermore, they are an integral part of the series. In the absence of fossil evidence, no division of the Potsdam seems possible in Clinton county, though it is far from certain that the whole is of Upper Cambrian age.

It is by no means impossible that rocks representing the Lorraine stage of the Hudson river group have been deposited on the west side of lake Champlain, but nothing younger than the Utica slate has yet been discriminated.

Potsdam sandstone. The Potsdam is widely exposed in the county, forming the rock surface in two townships and a large part of it in three others. Out of the fourteen towns making up the county, there is but a single one (Black Brook), in which this formation is wholly wanting. It is also found at very varying altitudes. At Coopersville and in the Ausable chasm it is close to the level of the lake, and at the former place the horizon

* American Geologist, October, 1895, p. 207, and Twenty-first Annual Report of Geological Survey of Minn., pp. 99 112.

PLATE II

SOUTH FACE OF SILVER LAKE MOUNTAIN, SHOWING ITS PRECIPITOUS CHARACTER.

PLATE III

GREAT CHAZY RIVER AT THOM'S CORNERS; SHOWING POTSDAM SANDSTONE IN STREAM BED AND BANK OF TILL.

is unquestionably near the summit of the formation. In Dannemora it is found at an elevation in the neighborhood of 1,500 feet, and in Ellenburgh, Beekmantown and Altona it runs nearly as high. Here, moreover, it is the base which is exposed.

The color is very varied, from white through various greys, yellows, browns and reds to even blackish appearing layers. Occasionally greenish layers, appearing somewhat glauconitic, occur. In general the reds prevail in the lower beds and are scarce above. The blackish varieties appear to be characteristic of the summit.

The main mass of the formation is made up of quite pure quartz sand. In the basal layers there is a large feldspathic content, mostly orthoclase, but with a little plagioclase and microcline. Occasional grains of pyroxene and hornblende and scales of biotite appear. In some layers zircon is prominent. Garnet has not yet been noted. The basal conglomerates are often very rich in magnetite. Toward the summit, dolomitic layers appear, regularly alternating with those of pure sand, and forming passage beds to the Calciferous above. Sometimes these are of pure dolomite, but prevailingly they are sandy, and the rather large rounded grains of quartz embedded in a fine mosaic of minute dolomite crystals furnish a striking combination in thin section. These dolomitic beds are not, however, confined to the higher layers, but occur sparingly elsewhere, even among red beds well toward the base, strata of such an appearance that it would scarcely occur to one to test them with acid; in fact, the presence of these layers was first made known by thin sections.

When the base of the formation is neared, massive conglomerates become prominent, sometimes attaining great coarseness. They are commonly interstratified with finer red, feldspathic, easily weathering beds, which are much permeated with hematite. It is a curious fact that the materials of which these basal conglomerates are made up are, so far as observed, always of gneissic origin, even when the contacts are with gabbro and a considerable distance from known gneissic outcrops.*

Along the lake these basal beds are seldom exposed, the contacts shown being largely brought about by faults, but on the north they have great prominence, especially in Ellenburgh (as noted by Emmons†), where they have considerable thickness, but by no means make up the whole mass, as stated by him.

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* See description of a conglomerate near Keeseville on a following page.

† E. Emmons.—Geology of New York, Second District, p. 309.

A noteworthy characteristic of this formation in the county, is the occurrence of quite pebbly layers at numerous horizons from the bottom to the top. The pebbles are almost invariably of quartz. At the base a few of orthoclase are mingled with them.

The various layers of the rock show great variation in their resistance to weathering. While the major part of the mass is well indurated and very durable, there are many layers in which the induration is much less, and which disintegrate quite rapidly to a coarse white sand. The most unstable portions are the red beds already mentioned as intermingled with the lower conglomerates. These have a large content of orthoclase derived from the gneisses, are permeated with hematite whose origin is uncertain, and break down rapidly to a red, hematitic, sandy clay, which is a very conspicuous feature along some of the roads.

The absolute thickness of the Potsdam hereabouts has not been determined with certainty. As it was deposited on an uneven, probably very uneven, floor, and as this floor was subsiding at the same time, its original thickness must have varied much from place to place. The thickest section susceptible of accurate measurement in the county, is that on the Ausable river where, according to Mr. C. D. Walcott, there is a thickness of 350 feet, with the base and summit not seen.* The impression conveyed by the widespread exposures in the northern part of the county is that the total thickness can scarcely fall short of 2,000 feet, and is quite likely much more. The possible presence of faults increasing the apparent thickness, renders it impossible to speak more definitely. If such are not present, the Potsdam is unquestionably more than 2,000 feet thick.

While it has been impossible to make an exhaustive search for fossils, a sharp lookout has been kept for them, and considerable time spent in the quest; yet none have been found except along the Ausable, where their presence has long been known. The Upper Cambrian age of the higher portion of the Potsdam has been shown, but there is as yet a complete lack of palæontologic evidence as to the age of the lower part.

The Calciferous sandrock. Rocks belonging to this division are spread over a considerable area in the tier of townships along the lake, but are unfortunately so concealed by Pleistocene deposits that the Potsdam-Calciferous boundary is almost completely obscured, and the Calciferous exposures are often disappointing, though excellent sections are exhibited in Beekmantown and Peru. Professors Brainard and Seely have carefully studied the

*C. D. Walcott, Bulletin 81, United States Geological Survey, p. 343.

Calciferous of the Champlain valley,* and their section at Shoreham, Vt., gives to the formation, which they separate into five subdivisions, a thickness of 1,800 feet. How large a part of this thickness the Calciferous possesses in Clinton county, can not be determined, but commonly the different exposures are correlated without difficulty with the various members of Brainard and Seely's section. The basal layers of the formation are shown in Champlain township, conformably overlying the Potsdam. In Peru and Beekmantown are good exposures of the higher and more fossiliferous members. The lower half or two-thirds is made up largely of grey, often sandy dolomites, quite barren of fossils. In the upper third, beds of limestone are mingled with the dolomite, and some sandy beds, weathering with thick yellow sandy crusts, also occur.

Chazy limestone. At Chazy village is the type section of this group which follows the Calciferous in ascending order. Brainard and Seely have, however, shown that the lower one hundred feet is lacking here and that the Valcour Island section is more complete.† Besides the excellent exposures in Chazy township the rocks of this group are also well shown in part just north of Plattsburgh, and on Bluff Point, two miles south of Plattsburgh, extending thence to the south into Peru, where the lower part of the formation is better shown than at any other point in the county on the mainland.

Brainard and Seely have recognized three subdivisions of the Chazy rocks, and their detailed section at Chazy village is reproduced on a later page. The lower subdivision is largely constituted of quite crystalline limestones of grey color, often full of crinoidal fragments and with *Orthis costalis* the most abundant fossil; the middle division is of blue-black fine-grained limestone and contains *Maclurea magna* at nearly all horizons; the upper division is quite variable in character, but is largely composed of somewhat impure blue limestones, carrying *Rhynchonella plena* abundantly.

The aggregate thickness of the Chazy limestone at Chazy village is 740 feet, with the base not shown. On Valcour Island, Brainard and Seely give it a thickness of 890 feet, and there it seems to reach its maximum.

For the most part these rocks are easy of recognition, and even small exposures may be assigned to their proper position without great trouble. There is a considerable quarry enterprise engaged in working the rocks of this group, some beds furnishing an ornamental marble, some a rough building stone, and some being burned for lime.

* Bulletin American Museum of Natural History, Vol. III., No. 1, p. 8.
† Bulletin Geological Society of America, Vol. II, pp. 293 to 300.

Black River limestone. The massive dark-colored beds of this rock are well exposed at numerous points in Chazy, directly overlying the Chazy limestone; but outside of this township it is not well exposed. It has a thickness of thirty to fifty feet and is a brittle, black limestone with conchoidal fracture. *Columnaria alveolata* is its most characteristic fossil, but is here confined to a single stratum a few feet thick, at about fifteen feet above the base. Above this is a zone with abundant large Maclureas and large masses of *Stromatocerium*, both of which are closely like the corresponding forms in the middle division of the Chazy, so that, unless care is taken, the two may be confounded, as was done by the writer in one or two instances. On smoothed, mere surface exposures the resemblance is very striking.

Trenton limestone. In Chazy and Plattsburgh townships are excellent exposures of portions of the Trenton. In the bed of the river just east of Chazy village, 150 feet are exposed lying on the Black river limestone. On Crab island, about 200 feet in thickness is exposed, the larger part of which is above the horizon of the beds at Chazy, while the lower fifty feet corresponds to the upper part of that section. The two together give a thickness of about 300 feet, but the summit is not shown. The faunas are being studied by Mr. T. G. White. In general the lower half is characterized by a brachiopod fauna, some bands being crowded with shells of *Leptæna sericea* and *Orthis.*

The upper one hundred feet of the Crab island section holds a lamellibranch fauna, with cephalopods and trilobites, while between the two is a zone with a sparse trilobitic fauna.

This lower portion of the Trenton is mainly made up of black, ringing, somewhat slaty limestone, the different layers presenting much variation in the latter respect.

In northeastern Plattsburgh, and extending into southeastern Beekmantown, occurs a series of black, quite slaty, calcareous rocks, which are excellently exposed on Cumberland Head. As there exposed they have had developed in them a slaty cleavage at a high angle with the bedding, which has already been described.* In Beekmantown this is not so pronounced, but is present. No base nor summit to these slates is exposed, and the stratigraphic evidence concerning their position is not decisive, but points strongly to their being of Trenton age, or, rather to their not being older than the Trenton. As the Chazy and Crab island sections furnish us with the basal 300 feet, and as there is an unknown vertical interval between the two, these

*H. P. Cushing. Report of New York State Geologist for 1893, vol. 1, p. 483.

slates must be well up in the Trenton. It will be impossible without prolonged study to arrive at a just estimate of their thickness here. The apparent thickness on Cumberland Head is very great; but there are also evidences there of much disturbance, and it is strongly probable that there is repetition. In addition to the evidence afforded by the slaty cleavage, one or two faults are plainly visible in the slates, and the topography strongly suggests others. Yet, taking all these things into consideration, 200 feet would be a very modest estimate of the thickness here displayed, and double, or even treble that amount would most likely be much nearer the true figure. The entire Trenton in this vicinity, therefore, must be very thick. The writer had the pleasure of conducting Mr. van Ingen to Cumberland Head, and to the exposures of these same slaty rocks in Beekmantown, and since the above was written a letter has been received from him giving the results of his study of their fauna. He pronounces the horizon to be high up in the Trenton, and with features in common with the "Quebec group" of Canada, so that it may turn out to be more nearly allied to the Utica slate than to the Trenton limestone; that is, the Utica as represented in Canada.

Utica slate. On Stony Point, in Champlain township, is an exposure of black, ringing, much-jointed calcareous slates, the joints largely filled with crystalline calcite, which carry the ordinary fauna of the New York Utica slate, *Triarthrus Becki*, *Climacograptus bicornis* and other graptolites, and *Endoceras*. With the exception of this single exposure, shut in on the east and north by the lake, and on the west and south by a marsh along a line of fault, no rocks known to be later than the Trenton limestone occur in the county. The Utica slate is also exposed on the east side of Isle la Motte.

Series V. The various types of dike rocks occurring in the lake Champlain district have been described at length by Kemp and Marsters,* and would need little mention here were it not for the fact that their study in Clinton county has emphasized certain facts regarding their distribution, which are not so apparent in Essex county and along the lake.

The dikes are readily separable into two classes; black, basic dikes of the varieties known as diabases, camptonites, monchiquites and fourchites, and lighter-colored acidic dikes, closely approximating the same type, and known as bostonites, the term being applied to the dike-form of feldspar porphyries or trachytes.

The acidic dikes known in Clinton county (twelve have so far been found) differ considerably from the typical bostonites as found and described

* Bulletin 107, United States Geological Survey.

by Kemp from along the lake.* Those have a prevailing light tint, creamy or brownish white or chocolate, and nearly or entirely lack magnetite and ferromagnesian silicates. The Clinton county dikes, on the contrary, are either red or mottled dark red and black, or purplish grey in color (one is nearly black), and with one exception contain considerable amounts of one or more of the minerals, magnetite, biotite, hornblende and monoclinic pyroxene in the ground-mass, and dike No. 9 even has porphyritic biotite. Some of them have a pseudo-schistose appearance. Most of them have porphyritic orthoclase, and this mineral makes up the main portion of the rock. The ground-mass has a trachytic structure, most marked around the phenocrysts. In these last two respects they agree with the typical bostonites, and they are not necessarily more basic because of the greater prominence of bisilicates, so that they are regarded as bostonites varying somewhat from the type, and seem to represent an intermediate stage between these type bostonites and the "granite" dikes described by Marsters from lake Memphremagog.†

Professor Kemp, some time ago, called attention to the fact that the basic dikes are more numerous in the Pre-Cambrian rocks than in the Palaeozoic series,‡ and further, in discussing the relations of diabase and camptonite, to the confining of the diabases to the former, and of the typical camptonites to the latter rocks. Many of the diabases of the region, however, grade strongly toward camptonites and augite-camptonites, and in two instances of this sort in Clinton county, the dikes are very narrow and seem almost certainly to be off-shoots from large dikes of typical diabase near by, recalling the camptonite apophysae from a laccolite of diabase described by Brögger.

The diabase dikes are found abundantly throughout Clinton county wherever the Pre-Cambrian rocks are exposed. The camptonites, monchiquites and fourchites seem to decrease in number north of Port Kent, and north of Plattsburgh are wholly lacking, in so far as negative evidence can be depended upon. This peculiarity of distribution, coupled with the fact that all along the northern line of contact between the Potsdam and the older rocks in the county the diabase dikes are found numerously on one side of the line and not at all on the other, has led the writer to elsewhere express the opinion that there were two periods of dike formation in this vicinity,§ one preceding and one following the deposition of the Palæozoic rocks of Series IV. The diabase dikes belong to the earlier, and the bostonites,

* These differences have been noted by A. S. Eakle, who described the first bostonite known in the county. American Geologist, July, 1893, pp. 32 and 33.

† V. F. Marsters, American Geologist, Vol. XVI., pp. 25-29.

‡ Bulletin 107, United States Geological Survey, p. 27.

§ H. P. Cushing, Transactions New York Academy of Sciences, Vol. XV., pp. 248-252.

monchiquites, fourchites and camptonites to the later period; though on account of the facility with which the diabases and camptonites shade into one another, it may not always be possible to determine to which of the two a given dike in the Pre-Cambrian rocks should be referred.

The diabase dikes are very common and widespread. Scarcely an outcrop of any extent of the Pre-Cambrian rocks can be found without disclosing the presence of one or more of them. But, as was to be expected, their distribution is irregular, as they are only occasional in certain areas, whereas others are fairly seamed with them. Sometimes a veritable plexus of dikes is exhibited, anastomosing in all directions, enclosing great horses of the country rock, and so variable from place to place that no satisfactory generalized measurements can be made. The most notable example in the county is in southeastern Altona township, where the Old Military road crosses the northeast spur of Rand's hill. Cutting the gabbro here is a grand exhibition of dikes, which will be more fully described under the discussion of that township.* Another striking exhibition of dikes is found along the west shore of Upper Chateaugay lake, and yet another on Dannemora mountain.

Appended is a tabulated list of the dikes found in the county by the writer. Kemp has noted the occurrence of others in the Lyon mountain iron mines, and two from Palmer hill, and three others have been described by Eakle.

* See E. Emmons. Natural History of New York, Geology, Part II., p. 28.

No.	Township.	Locality.	Width.	Strike.	Walls.	Name.	Remarks.
5	Altona	First gneiss exposure on edge of Rand's hill by turnpike, going northwest. School district No. 5	3 ft. ±	N. 80° E.	Gneiss	Diabase	
6	Altona	West of road, 30 yards south of No. 5	3 ft. 6 in.	N. 80° E.	Gabbro	Diabase	Quite decomposed.
7	Altona	By-road, 110 yards north of No. 5	2 ft. 7 in.	S. 80° E.	Gabbro	Bostonite	Porphyritic. Has considerable hematite and some chlorite. Is faulted for its own width.
8	Altona	Begins 140 yards beyond No. 7, east of road	40 ft. +	N. 60° E.	Gabbro	Diabase	Dike described on page 565. For a width of 150 yards the gabbro is all split up by its branches.
9	Altona	10 yards north of No. 10, showing on east side of road	10 ft. 3 in.	N. 60° E.	Gabbro	Bostonite	Phenocrysts of orthoclase and biotite. Much biotite, some apatite and diopside in ground-mass. Trachytic structure not well marked.
10	Altona	Where lane up Rand's hill leaves turnpike, not far south of School No. 5	8 ft 4 in.	N. 60° E.	Gabbro	Diabase	Faulted 4 feet at the road.
11	Altona	⅛ mile northwest of schoolhouse, 40 yards south of small stream along Gabbro-Potsdam contact	5 ft. 2 in.	N. 50° E.	Gabbro	Diabase	Much decomposed.
12	Altona	20 yards north of No. 11 and somewhat nearer the road	15 ft.	N. 50° E.	Gabbro	(?)	Not a dike, but a shear-zone in the gabbro.
13	Altona	A little southeast of No. 11, on the east side of road	8 ft. ±	S. 80° E.	Gabbro	Olivine diabase	Coarsely porphyritic. A dike plexus of several branches, the whole occupying a width of 75 ft.
14	Altona	50 feet north of No. 15	6 ft. ±	N. 65° E.	Gabbro	Olivine diabase	A variable dike plexus instead of a single dike.
15	Altona	At School No. 5	2 ft. 10 in.	S. 80° E.	Gabbro	Olivine diabase	Porphyritic olivine, augite and plagioclase phenocrysts.

No.	Township.	Locality.	Width.	Strike.	Walls.	Name.	Remarks.
16	Altona	¼ mile up lane, ascending Rand's hill, just south of school-house	8 ft.	N. 75° E.	Gabbro	Diabase	
17	Altona	120 yards further up lane	4 ft. 10 in.	N. 60° E.	Gabbro	Diabase	In three branches, two of them of 1 foot each.
18	Altona	8 yards north of Dike No. 7	3 ft. 8 in.	S. 80° E.	Gabbro	Diabase	Decomposed.
68	Au Sable	Back of Mr. Keese's house	5 ft. 9 in.	S. 15° E.	Gabbro	Diabase	Has two parallel branches each 15 in. wide. Approaches augite camptonite.
69	Au Sable	Extreme northeast part of gabbro area	3 in.	S. 80° E.	Gabbro	Diabase	
72	Au Sable	¼ mile southeast of School No. 5, west of Keeseville, and 100 yards south of road	3 ft.	N. 80° E.	Gabbro	Diabase (?)	Highly decomposed.
75	Au Sable	Near road at toll gate, ¾ mile east of Dike No. 76	1 ft. 9 in.	N. 60° E.	Gabbro	Olivine diabase	Porphyritic; much decomposed.
76	Au Sable	River bank at big bend, 2¼ miles west of Keeseville, close to river road; Sec. 20	3 in.	N. 70° E.	Gabbro	Diabase	Porphyritic.
77	Au Sable	200 yards northeast of Dike 78	2 ft.	N. 60° E.	Gneiss	Diabase	
78	Au Sable	Close by river road just east of Clintonville	2 in.	N. 65° E.	Gneiss	Diabase	
79	Au Sable	½ mile north of Clintonville, just west of road	3 ft. 6 in.	N. 50° E.	Gneiss	Diabase	Amygdaloidal; much biotite and some brown hornblende in ground-mass.
80	Au Sable	100 yards north of first house on road north of Clintonville	6 ft. 5 in.	N. 60° E.	Gneiss	Olivine diabase	Porphyritic.
105	Au Sable	Back of Mr. Keese's house, not far from No. 68	2 ft.	S. 30° E.	Gabbro	Diabase	A network of small branches bearing in all directions.

No.	Township.	Locality.	Width.	Strike.	Walls.	Name.	Remarks.
27	Beekmantown.	Northwest part of School district 7, ½ mile west from road	20 ft.	E.	Gneiss	Bostonite	Very large orthoclase phenocrysts; augite, hornblende and biotite in ground-mass.
28	Beekmantown.	Rand's hill, near Mr. Sanger's	6 ft.	S. 75° E.	Gabbro	Bostonite	Contains sparse augite phenocrysts, and a small amount of hornblende in the ground-mass.
29	Beekmantown.	40 yards north of No. 28	1 ft. 10 in.	E.	Gabbro	Bostonite	12 feet exposed at the surface; the east half is faulted 6 ft. to the south. Contains magnetite and hornblende.
30	Beekmantown.	Not far from last	(?)	(?)	Gabbro	Diabase	Highly decomposed, and poorly exposed.
31	Beekmantown.	Near Mr. Golden's	1 ft.	N. 80° E.	Gneiss	Bostonite (?)	Contains much biotite and green hornblende, and appears very basic for a bostonite. Has orthoclase phenocrysts.
103	Beekmantown.	Near summit of road, 3 miles south of Jericho	3 ft. 9 in.	S. 80° E.	Gneiss	Bostonite	Considerable magnetite and numerous small green hornblendes in ground-mass. Excellent flow structure.
104	Beekmantown.	Close to Dike No. 27	(?)	(?)	Gneiss	Diabase (?)	Badly decomposed and not well exposed.
81	Black Brook ..	200 yards north of School No. 6, ½ mile west of Au Sable town line	1 ft.	S. 10° E.	Gneiss	Diabase	Approaching augite camptonite. Two small branches found, both pinching out.
82	Black Brook ..	First dike in gneiss exposure just east of Au Sable Forks along railroad	10 in.	N. 60° E.	Gneiss	Diabase	Closely approaching augite camptonite.
83	Black Brook ..	150 yards east of No. 82	2 ft. 6 in.	N. 65° E.	Gneiss	Diabase	Where seen was in four divisions.
84	Black Brook ..	Several rods east of No. 83	6 ft.	N. 65° E.	Gneiss	Diabase	Porphyritic; very fresh material to be obtained.

No.	Township.	Locality.	Width.	Strike.	Walls.	Name.	Remarks.
85	Black Brook ..	At east end of gneiss outcrops along river, just east of the Forks	6 ft.	N. 55° E.	Gneiss	Diabase.....	Many included horses of gneiss.
86	Black Brook ..	By road just north of Black Brook village, east side of brook	1 ft.	N. 20° E.	Gneiss	Olivine diabase .	Large augite phenocrysts; quite fresh.
87	Black Brook ..	Just north of fork in road, a few rods south of No. 88....	9 in.	S. 35° E.	Gneiss	Diabase.....	Closely approaching augite camptonite.
88	Black Brook ..	By road, where outlet of Slush pond enters Black brook....	2 ft.	N. 65° E.	Gneiss	Diabase.....	Similar to No. 89, and probably a branch of that.
89	Black Brook ..	7 yards south of No. 88	(?)	N. 65° E.	Gneiss	Diabase.....	.....
90	Black Brook ..	A few rods west of Mr. Fitzgerald's; Sec. 46.....	7 ft.	N. 65° E.	Gneiss	Diabase.....	Porphyritic.
92	Black Brook ..	¼ mile west of Clayburgh, a few yards south of road.	4 in.	S. 85° E.	Gabbro	Diabase.....	Greatly decomposed.
93	Black Brook ..	By south branch of Saranac river, on west bank, ¼ mile above junction with west br.	2 ft. 6 in.	N. 65° E.	Gneiss	Diabase.....	Badly decomposed.
94	Black Brook ..	In Boyne ore-bed near Williamsburg	(?)	(?)	Gneiss	Olivine diabase .	From dump. Not seen in place.
19	Crab Island...	South end of island in loose blocks.....	(?)	(?)	Trenton limestone.	Fourchite.....	Amygdaloidal. Augite in two generations, with biotite and magnetite; olivine infrequent; no hornblende; analcite.
20	Dannemora ...	In wall of pit back of Clinton prison	1 ft. 8 in.	N. 70° E.	Gneiss	Diabase.....	Large plagioclase phenocrysts.
24	Dannemora ...	First dike seen by road over Dannemora mountain, ¾ mile north of Dannemora.....	4½ in.	E.	Gneiss	Diabase.....	Much decomposed.
21	Dannemora ...	50 yards north of No. 24	15 in.	N. 80° E.	Gneiss	Bostonite	Considerable magnetite, but no ferro-magnesian silicates.

No.	Township.	Locality.	Width.	Strike.	Walls.	Name.	Remarks.
22	Dannemora ...	100 yards north of No. 21	2 ft. +	E.	Gneiss	Diabase.....	.....
23	Dannemora ...	Over ½ mile north of No. 24, and 25 rods north of No. 25.....	4 ft. 2 in.	N. 55° E.	Gneiss	Diabase (?)	Very much decomposed.
23a	Dannemora ...	10 ft. north of No. 23.....	9 in.	N. 55° E.	Gneiss	Diabase.....	Presumably a branch.
25	Dannemora ...	Near summit, 25 rods south of No. 23	6 ft. (?)	E.	Gneiss	Bostonite	Porphyritic orthoclase; considerable biotite and hornblende.
26	Dannemora ...	Northwest of road on west side of lower end of Chazy lake....	15 ft.+	E. (?)	Gneiss	Olivine diabase.	Seams the gneiss in all directions for a width of 50 feet. Porphyritic augite.
46	Dannemora ...	Roadside east of creek at Lyon mountain village	20 ft. (?)	N. 55° E.	Gneiss	Diabase.....	Dark-colored; much hornblende and biotite as inclusions; some hornblende secondary after augite; apparently some plagioclase.
50	Dannemora ...	Just beyond west end of ore-pit close to Lyon mountain depot	3 ft. 6 in.	N. 50° E. (?)	Gneiss	Diabase.....	Does not fault the ore.
51	Dannemora ...	17 yards west of No. 50.....	(?)	N. 50° E. (?)	Gneiss	Diabase.....	Compass readings affected by the ore-body.
52	Dannemora ...	200 yards west of No. 51	6 ft. 10 in.	N. 50° E. (?)	Gneiss	Olivine diabase.	.....
53	Dannemora ...	Near south end of Chateaugay railroad cut on hillside at head of Upper Chateaugay lake.....	6 ft.	E.	Gneiss	Diabase.....	.....
54	Dannemora ...	9 yards north of No. 53	2 ft. 1 in.	N. 15° E.	Gneiss	Diabase.....	.....
55	Dannemora ...	85 yards north of No. 54	5 ft.	N. 70° E.	Gneiss	Diabase.....	.....
56	Dannemora ...	55 yards north of No. 55	11 in.	S. 80° E.	Gneiss	Olivine diabase.	.....
57	Dannemora ...	75 yards north of No. 58	5 ft.	S. 80° E.	Gneiss	Diabase.....	Decomposed.
58	Dannemora ...	300 yards north of No. 56	2 ft. (?)	N. 85° E.	Gneiss	Diabase.....	Decomposed.

...ship.	Locality.	Width.	Strike.	Walls.	Name.	Remarks.
...ore ...	...t boat house, Indian Point hotel ...	4 ft. 7 in.	N. 80° E.	Gneiss	Diabase.....	Dikes 59 to 67 are all shown on the west shore of Upper Chateaugay lake. It is uncertain which two Mr. Eakle described.
...ore ...	...17 yards south of No. 59	2 ft. 3 in.	N. 80° E.	Gneiss	Diabase.....	Much like No. 59.
...ore ...	...30 yards north of No. 59	2 ft. 6 in.	E.	Gneiss	Diabase.....	Porphyritic.
...ore ...	...30 yards south of No. 61	2 ft.	E.	Gneiss	Diabase.....	.....
... ...	...30 yards north of No. 61	3 ft. 6 in.	N. 80° E.	Gneiss	Diabase.....	Porphyritic. Similar to No. 61.
	...25 yards north of No. 63	3 ft.	N. 75° E.	Gneiss	Diabase.....	Like No. 61.
	...0 yards north of No. 64	3 ft.	S. 80° E.	Gneiss	Diabase.....	Porphyritic.
30	...0 yards north of No. 65	2 ft. 5 in.	N. 70° E.	Gneiss	Olivine diabase	Approaching camptonite; idiomorphic hornblende in ground-mass.
31	Sara...	9 in.	E.	Gneiss	Diabase.....	Dikes 59 to 67 are all shown on the west shore of Upper Chateaugay lake. Two of them were described by Eakle, but which two is not certain.
3...	Saranac					
36	Saranac	1 ft. 6 in.	N.	Gneiss	Olivine diabase	Porphyritic feldspar and olivine; quite fresh.
37	Saranac	7 in.	N. 15° E.	Gneiss	(?)	Cataclastic structure; either a sheared dike or shear-zone in gneiss.
38	Saranac	15 ft.	S. 75° E.	Gneiss	Diabase.....	.....
39	Saranac		N. 70° E.	Granite	Bostonite	Numerous large orthoclase phenocrysts; considerable green hornblende in the ground-mass.
40	Saranac		S. 60° E.	Granite	Diabase.....	Very fresh; augite quite pleochroic.

...ast side of road south from ...'s, opposite Mrs. ... nearly ½ miles from ...

...west side of No. 10, near by-...

10 yards ... brook

1 mile west of ... True brook

10 yards west of No. 38 ...

Just west of third bridge over True brook

No.	Township.	Locality.	Width.	Strike.	Walls.	Name.	Remarks.
97	Ellenburgh ...	On south side of West hill, close to the road near Mr. Secor's	2 ft. 5 in.	E.	Gneiss	Diabase.....	Grades into augite camptonite; is faulted.
98	Ellenburgh ...	120 yards north of No. 97	3 ft.	N. 80° E.	Gneiss	Olivine diabase .	This and the succeeding three are very similar, somewhat amygdaloidal.
99	Ellenburgh ...	160 yards north of No. 98	3 ft.	N. 70° E.	Gneiss	Olivine diabase .	.....
100	Ellenburgh ...	75 yards north of No. 99	15 ft.	E.	Gneiss	Olivine diabase .	.....
101	Ellenburgh ...	25 yards north of No. 102	5 ft.	N. 65° E.	Gneiss	Diabase.....	Porphyritic feldspars of large size; branches of very variable width.
102	Ellenburgh ...	¼ mile southwest of Star P. O.	3 ft.	S. 75° E.	Gneiss	Diabase.....	In four branches of 3 ft., 2 ft., 2 ft. and a few inches respectively.
2	Peru	In first field south of Day's quarry, near lake.....	4 ft.	S. 70° E.	Chazy limestone...	Camptonite	Not fresh.
3	Peru	80 rods south of No. 2, in field between road and lake.....	3 ft.	N. 80° E.	Chazy limestone...	Monchiquite....	Considerable olivine; some biotite and brown hornblende in the ground-mass in addition to augite.
44	Peru	North slope of Terry mountain, ½ mile south of Ormsbee's house	7 in.	N. 15° E.	Gneiss	Diabase.....	Probably a branch of 45.
45	Peru	Close to No. 44	1 ft. 6 in.	S. 85° E.	Gneiss	Diabase.....	Faulted twice within a few feet.
71	Peru	A few rods back of Eell's house	3 ft. 10 in.	N. 60° E.	Gneiss	Diabase (?)	Highly decomposed.
70	Peru	⅛ mile south of No. 71.....	4 ft.	N. 10° E.	Gneiss	Diabase.....	Is faulted 4 feet.
73	Peru	By road north of east edge of Mount Etna	10 ft. (?)	N. 60° E.	Gneiss	Diabase.....	Decomposed.

No.	Township.	Locality.	Width.	Strike.	Walls.	Name.	Remarks.
74	Peru	About the centre of School District No. 11	17 ft. (?)	N. 70° E.	Gneiss	Olivine diabase	Approaching camptonite; porphyritic and fresh; idiomorphic brown hornblende and biotite in the ground-mass; is in eight divisions averaging 5 yds apart.
1	Plattsburgh	By road from Plattsburgh to Bluff Point, 125 yards north of Bluff Point railway station	5 in.	S. 80° E.	Chazy limestone	Monchiquite	Abundant olivine; quite fresh material may be obtained.
4	Plattsburgh	Toward south end of Trenton exposures along lake just north of Bluff Point	2 ft. 9 in.	E.	Trenton limestone.	Fourchite	Olivine seldom; little biotite, but no hornblende; much analcite.
32	Saranac	Just north of road east of Saranac village, near Saranac bridge	10 ft.+	S. 80° E.	Gneiss	Bostonite	Contains considerable green biotite.
33	Saranac	Just east of Russia, north of road	4 ft.	S. 40° E.	Gneiss	Diabase	Much decomposed; gneiss is brecciated along contact.
34	Saranac	By the Saranac river, 40 rods above the High falls	5½ in.	N. 80° E.	Gneiss	Diabase	.....
35	Saranac	20 yards south of No. 34	3 in.	N. 80° E.	Gneiss	Diabase	Two divisions, one of 2 in., the other 1 in.
36	Saranac	100 yards east of first bridge over True brook, by the roadside	(?)	S. 80° E.	Gneiss	Diabase (?)	Only fragments close to the gneiss are preserved, showing glass with microlites.
37	Saranac	40 yards south of No. 36 by the brook	6 ft.	N. 85° E.	Gneiss	Diabase	Considerably decomposed.
38	Saranac	½ mile west of first bridge over True brook	3 ft.	N. 85° E.	Gneiss	Diabase	Decomposed; much epidote in the slide.
39	Saranac	10 yards west of No. 38	3 ft. 4 in.	N. 85° E.	Gneiss	Diabase	Decomposed.
40	Saranac	Just west of third bridge over True brook	9 ft.+	N. 80° E.	Gneiss	Olivine diabase	In three divisions, the largest 7 ft. 2 in.

No.	Township.	Locality.	Width.	Strike.	Walls.	Name.	Remarks.
41	Saranac.....	A branch of No. 40.....	2 ft. 2 in.	N. 80° E.	Gneiss	Olivine diabase.	Typical; quite fresh, even the olivine being partly unchanged; porphyritic augite and olivine.
42	Saranac.....	80 rods west of No. 40.....	2 ft. 4 in.	N. 70° E.	Gneiss	Diabase.....	Decomposed.
43	Saranac.....	....	.....	.....	Gneiss	.....	Not a dike, but basic gabbro, sheared.
91	Saranac.....	By Cold brook, near its mouth.	1 ft.	S. 25° E.	Gneiss	Diabase.....	Has two small branches of 2 in. and 6 in. respectively; much decomposed.
106	Saranac.....	Just east of south end of Redford bridge.....	1 ft.	S. 80° E. (?)	Gneiss	Diabase.....	Porphyritic augite.
107	Beekmantown.	Close to No. 103	(?)	(?)	Gneiss	Bostonite	Flow structure poor. Contains magnetite and considerable green hornblende.

Series VI. There has not been sufficient time at my command to bestow on the Pleistocene deposits the attention they deserve. They are widespread throughout the county, often in sufficient force to completely obscure the underlying geology over considerable areas. They were, in part, formed by glaciers and the streams to which they gave rise; in part, in the body of standing water which occupied the Champlain valley just after the retreat of the ice, and which had, at first, a level much above that of the present lake, when it was probably fresh water, while later it was an arm of the sea.

Glacial deposits. Away from the lake, the county is covered with a heavy deposit of till. Over the high plain it is widely extended and largely masks the irregularity of its pre-glacial surface. In the hilly tract it is mainly confined to the valleys, though often prominent on the gentle northern slopes of the ridges. Sections show it to be mostly very stony and very sandy, as might be expected from the wide expanse of Potsdam country over which the ice moved.

Moraines have been noted at various points, but any attempt at mapping them would be premature. Much of the surface of the high plain is insufficiently drained, abounding in swamps, some of very large extent. Rough, jagged boulders, mainly of Potsdam sandstone, are widespread over the surface, often forming veritable trains, and being exceedingly numerous. Some of these Potsdam boulder trains extend well into the gneiss country.

Glacial striae have been observed at many points. They are commonly well preserved on the palaeozoic rocks, but none have been noted on the older rocks, although these are often well polished and smoothed. Along the lake their direction is approximately that of its trend, those observed varying from S. 15° E. to S. 15° W. and those on the high plain have the same general direction. As the hills are neared and entered, however, the general direction is to the southwest, corresponding to the general trend of the ridges and valleys.

A magnificent, long, esker-like ridge, which well merits description,* occurs in the county. It is found in the low strip, only two or three miles back from the lake, and forms a topographic feature of sufficient prominence to be clearly brought out by the twenty-foot contours of the new maps. First recognizable in Beekmantown township about two miles south of Ingraham post office, it runs north in a curve to that point, then bears to the west of north through Chazy. In the central part of that township its course is

*Mr. S. P. Baldwin has noted the presence of this ridge. American Geologist, March, 1894, p. 177.

interrupted by a wide marsh, and by protruding ledges of rock, but after an interval of a mile it again appears and runs north to the Chazy-Champlain line, finally disappearing one-half mile beyond that line. It rises, in general, about thirty feet above the ordinary level and the base has a width of a quarter of a mile. Its surface is 120 feet above the level of lake Champlain. It does not exhibit its entire mass, as its base is buried in Champlain clay. Assuming that the disconnected portions are parts of a single ridge, as seems highly probable, its entire length is ten miles. No good sections are exposed. A three-foot cut in it, two and one-third miles southwest of Chazy village, frequently shows somewhat rounded boulders mostly of Potsdam sandstone, a few of which reached one foot in diameter, embedded in a matrix of coarse, brown sand. No signs of stratification were visible, but the opening was not a very recent one.

Champlain deposits. The term "Champlain," as here used, merely serves to discriminate the deposits formed under water in the Champlain basin, from those formed upon the land. During and after the retreat of the ice, the glacial deposits on the low strip were covered by deposits laid down in the marginal portions of the body of water that occupied the basin at that time, the present lake being its shrunken remnant. The mountain streams brought down vast quantities of sand, building up large deltas at their mouths, and of mud, which was deposited farther out and also along shore between the deltas. As the water level fell from time to time, the sand deposits were pushed farther out and formed at lower levels, covering up the clays of the preceding stages. During much of this time the Champlain basin was occupied by an arm of the sea, and the marine clays and sands are fossiliferous. The fossils can be collected in abundance at several points in the county. The sand delta deposits formed by the Saranac, Ausable, Little Ausable and Salmon rivers are very widespread in the eastern part of the county. At the higher levels they are confined to their respective valleys, but lower down they become confluent. Much of the eastern portions of Ausable, Peru, Schuyler Falls and Plattsburgh townships is covered by a wide, dreary expanse of sand, often bare, sometimes with a sparse covering of coarse grass with huckleberries and stunted pines, and which is dreary and monotonous in the extreme. Dunes are quite frequent, especially where the sand has been trenched by the present streams.

Some of the evidence collected indicates that at first the water level was at a greater altitude than has heretofore been recognized. Both in the Saranac and Ausable valleys, the sands have been found to run up to

the height of 1,000 feet, and some of them are in such situations that they can not possibly be regarded as river gravels and sands. This matter needs further investigation.

METAMORPHISM OF THE PRE-CAMBRIAN ROCKS.

After the intrusion of the gabbro, and prior to the commencement of Potsdam deposition, the region was subjected to intense dynamic metamorphism. The precise results produced would vary with the physical and chemical properties of the rocks concerned, but, broadly speaking, they consisted in the foliation of the rocks and the granulation of their contents, with or without subsequent recrystallization. The gneisses were granulated and subjected to a stretching process, by means of which the foliation and some, at least, of the banding was produced; rocks like the gabbro dikes being drawn out like the rest, and made to appear like an integral part of the series. While some of the gneiss is characterized by a cataclastic structure, other portions of it seem to have been completely recrystallized, and the different minerals seem for the most part to have formed at the same time, few, if any of them, showing idiomorphic boundaries against the rest. That this recrystallization was not the final result of the metamorphism, is shown by the frequent pronounced undulatory extinction shown by the component minerals of such rocks.

The anorthosites and gabbros were granulated and stretched in the same manner as the gneisses, though apparently being more resistant to the latter process. In the less feldspathic anorthosites, foliation was thus produced, giving them their gneissoid aspect, and in them more or less recrystallization took place with the formation of minerals foreign to the parent rock, by the reactions of the various constituents on one another, much garnet, hornblende and biotite thereby resulting. The stages of the process of granulation can be studied to as great advantage in the Clinton county anorthosites as in the Canadian examples so exhaustively described by Dr. F. D. Adams.

The basic gabbros seem to have been characterized originally by an ophitic structure, but as a rule they are more thoroughly and finely granulated than the anorthosites. They are often of such fine grain, and their boundaries against the enclosing rocks are so sharp that the resemblance to dikes is very striking. Reaction rims are a prominent feature in these rocks. They almost always contain hypersthene, which is not common in the anorthosites and less basic gabbros. In many cases the rock seems to have undergone complete

recrystallization, and when this is the case a considerable amount of untwinned feldspar is present.

These basic gabbros vary in grain down to very finely granular varieties, which are identical in character with the "shear-zone" rock from Avalanche lake, described by Kemp.* A regular series can be made out from rocks with ophitic structure down to these finely granular varieties. It seems to the writer that these shear-zone rocks must have been originally of the basic, ophitic type, and then they are often found in this much granulated condition because less resistant than the massive anorthosites to the forces acting on the rock. Where such bands are present they would represent lines of weakness. But their different mineralogic composition is not regarded as resulting from such action, but as largely a primary difference.

These gabbros may be regarded as basic segregations from the anorthosite magma, or they may represent a period of igneous activity subsequent to the anorthosites. They certainly have a much wider distribution. So far as the writer is aware, data are lacking at present by means of which either of these propositions may be demonstrated at the expense of the other. Later observations by both Professor Kemp and the writer, clearly show that these ophitic gabbros are younger than the anorthosites.

If the writer is correct in his belief that the diabases are of Pre-Cambrian age, they must have followed the metamorphism of the rocks, as they are not affected by it.

Post-Ordovician Disturbance.

After the deposition of the Palaeozoic rocks, came the period of the Green mountain uplift in Vermont, and its effects were felt on the western side of lake Champlain. Though but a comparatively few miles west of the district in western Vermont characterized by sharp folds and thrust faults, the effects shown here are apparently limited to normal faulting, accompanied by a very trivial amount of folding. The dip of the Palaeozoic rocks is but slight, seldom reaching ten degrees, and more commonly not over five degrees, and is prevailingly to the north. Higher dips do occur, but are invariably local and in almost every observed instance can be demonstrated to be due to proximity to a fault. Very low folds are often to be made out, but can hardly be considered as constituting a prominent structural feature. Further—

PLATE IV

ANORTHOSITE ON HALLECK'S HILL; SHOWING THE WELL GLACIATED SURFACE,

PLATE V

NEARER VIEW OF THE SAME.

gnificant breaks, to great dislocations which have a throw of 2,000 feet, l possibly more, and which can be traced for several miles. The possibility the presence of thrust faults has been constantly borne in mind, but the dence for their existence has not been forthcoming. In the majority of es the hade of the fault is not to be made out, but it is at least high. Some be demonstrated to be normal faults. By them the palaeozoic rocks are pped up into a series of small blocks, and they are so prevalent that enever the rocks are concealed much uncertainty necessarily prevails as to at is beneath. It may, however, be laid down as a general proposition t, in passing eastward from the Pre-Cambrian rocks toward the lake, gressively younger rocks are met with. The exceptions to this in the nty are but few. The greater breaks have a northeast and southwest, or orth and south trend, while the smaller ones range at some angle to these, so far as observed do not pass across them.

The Pre-Cambrian rocks have necessarily suffered also from the disturnces of this period, but in them the fractures are often difficult to locate, is it possible to definitely distinguish them from possible earlier faults. e topography often implies faults of great magnitude, but is wholly silent to their date. Kemp has written of the frequent faulting of the ore-beds. ng contacts, too, decisive evidence of faulting is often forthcoming. The es are often faulted, the shift at the surface varying from a few inches only to the complete disappearance of the dike on one side of the break. ese faulted dikes give us the only evidence of faults which can, with tainty, be ascribed to the later period.

TOWNSHIP GEOLOGY.

The more prominent features of the local geology in the various townps will now be considered. The townships, in alphabetical order, are as lows:

Altona, ...	Page 562	Dannemora, . .	Page 535
Ausable, ...	" 545	Ellenburgh, . .	" 533
Beekmantown, . .	" 559	Mooers, ...	" 532
Black Brook, . .	" 541	Peru, ...	" 549
Champlain, . . .	" 571	Plattsburgh, . .	" 553
Chazy, ...	" 566	Saranac, ...	" 538
Clinton, ...	" 532	Schuyler Falls, .	" 552

Clinton.

The geology of this township is of no special interest. The Potsdam sandstone is the surface rock throughout, and the exposures are few and meagre. The eastern half of the township is swampy and heavily wooded. The central and western parts are higher and quite largely cleared of timber, but are deeply covered with till.

Mooers.

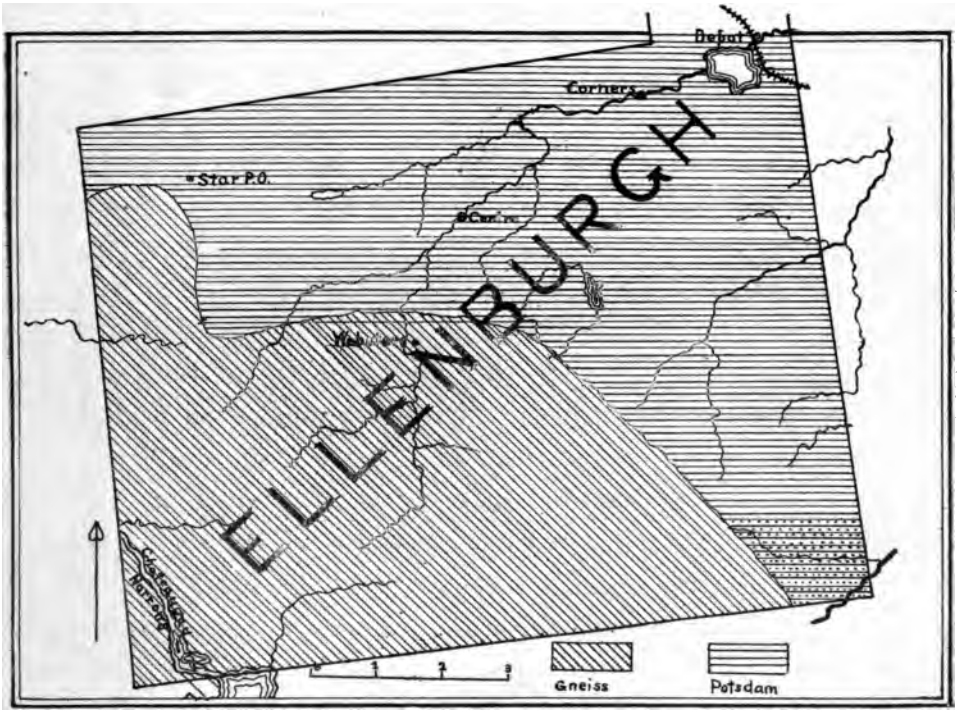
In this township, also, the Potsdam is everywhere the surface rock, but the exposures are better, more frequent, and somewhat more varied in character than in Clinton. Both townships form part of the high plain which slopes north from the Adirondack foot-hills. The dips are chiefly to the northwest, but the presence of slight folds is indicated by the occasional occurrence of southeasterly dips. North of Mooers village occurs a series of interesting passage beds to the Calciferous, with a breadth of outcrop at the Canada line of nearly three miles. They are cut off sharply on the west, their place being taken by ordinary Potsdam, thus indicating a fault as the dip to the northwest. They consist of rapidly alternating layers of white or buff, well indurated sandstone, and dark bluish grey dolomites, which are often sandy, the sandstones predominating. The dolomite layers, when forming the surface, have a peculiar habit of weathering, which may also be frequently observed in the dolomites of the Calciferous. Solution takes place rapidly along two sets of planes, approximately at right angles, until the entire thickness of the bed is eaten through (these dolomitic layers here have no great thickness, seldom more than a foot), so that it is converted into a regular series of disconnected blocks, of rounded outline, which project above the meagre soil and present a very curious and striking appearance.

If the Potsdam sandstone runs across the township without having its apparent thickness increased by faulting, the minimum thickness that can be assigned to it is 1,500 feet, with the summit not reached, and the base not even closely approached.

The township is quite heavily drift-covered. Along the streams in its eastern half, considerable sand is exposed, but nothing at all comparable to the great accumulations of the Saranac and the Ausable rivers. At Thorn's Corners, two miles west of Mooers village, the Great Chazy river shows Potsdam sandstone in the stream bed, and over it on the bank an excellent section, twenty-five feet in height, the upper ten feet consisting of coarse cross-bedded gravels, overlying a stony and rather sandy till.

Ellenburgh.

Series I. The gneisses enter Ellenburgh from the south as three northeasterly trending ridges. Ellenburgh mountain on the east, Panther mountain in the centre, and on the west the less conspicuous ridge which forms Sanborn's hill and West hill. The ridges are separated by wide drift-filled valleys, in which occasional rounded and glaciated knobs of gneiss protrude above the surface. The Ellenburgh mountain gneiss, and that in the valley to the west of it, is the ordinary red, microperthitic gneiss of the Adirondacks, very acidic, poorly foliated, and cut by numerous veins of coarse pegmatite



and quartz. The pronounced red color of much of the rock is found to be due to the infiltration of hematite between the grains and into the cleavage cracks of the feldspar.

The gneiss of Panther mountain and West hill is highly acidic and much of it looks like a red granite, and contains nothing besides microperthitic orthoclase and quartz. In the more gneissoid exposures a monoclinic pyroxene of strong green color creeps in. Very basic bands are not very numerous and are, so far as observed, hornblende-plagioclase gneisses, generally having this same green pyroxene in addition. The magnetite grains

which occur in these gneisses are often surrounded by rims of titantite, indicating that they are titaniferous, and this is frequently the case in these gneisses throughout the whole region.

The facility with which gabbro grades into diorite has been shown by several observers. These hornblende gneisses of the Adirondacks seem also to grade into gabbro-gneisses whose igneous origin and relationship with the greater gabbro masses are regarded as certain, and it is quite probable that the hornblende-gneisses will prove to be merely a phase of them.

Series II and *III* are not known to occur in the township, though it is quite likely that basic gabbros may be found in the gneisses.

Series IV. All the northeastern half of the township is occupied by the Potsdam sandstone, with prevailing dips of from 5° to 10° to the N. W. The striking feature of the Ellenburgh Potsdam is its coarseness, even at considerable distances from the gneiss, so that heavy conglomerates here range through a thickness of 200 feet or more. A quarter of a mile west of Star post office, and 200 yards south of the road, the Potsdam is found within fifteen yards of the gneiss, a slight depression with no rocks exposed lying between. The Potsdam is not as coarse as might be expected so close to the contact, no coarser in fact than is the larger part of the formation in the township. This, together with the somewhat abnormal dip of the sandstone at this place, gives rise to the suspicion of a north and south fault here (the Potsdam lies to the east of the gneiss), and such a fault would explain the sudden shoot to the north which the gneiss takes along this line.

In addition to the prevailing coarseness, much of the rock is very feldspathic, as is the case throughout the county in the basal Potsdam. The less coarse, rapidly disintegrating, hematitic beds which frequently accompany the conglomerates make, however, little show in this township. But there is often a rapid alternation of coarse and finer beds, giving a thin-bedded character to much of the coarse rock.

In the extreme northeast the conglomerates are left behind, and the rock consists almost wholly of quartz sand. Yet even here certain horizons are very pebbly. A very interesting exposure of the sort occurs in the bed of the English river at Ellenburgh depot. The dip here is slight and the surface of a single layer is exposed over many square yards. The rock is a coarse, even-grained grit but is set with numerous pebbles of white quartz, sometimes over two inches in diameter. The horizon is well above the base and affords a good instance of the coarse character which the rock holds throughout. In addition to the quartz pebbles three larger rounded masses of *sandstone*, from

four to six inches in diameter, were also observed embedded in the layer, as well as two smaller pebbles of the same character.

Series V. Of the eleven dikes found in the township only three call for any comment. Two miles from Webster's mill, on the road west, an enormous bostonite dike is exposed just north of the road. It is fully thirty feet in width, has a dark reddish hue, and contains much porphyritic orthoclase, the crystals ranging up to one inch in length. Besides furnishing a magnificent example of these dikes, it is also of interest for its indication of the wide distribution of the bostonites. Just south of this dike, by the roadside, is a dike of diabase (No. 96), two feet wide, which furnishes quite fresh material, and is noteworthy for the strong pleochroism of its porphyritic augite. One-fourth of a mile southwest of Star post office is a diabase dike (No. 102), which furnishes the largest feldspar phenocrysts observed in any diabase in the county. They are numerous, occur up to an inch in length, breaking with lustrous cleavage faces which beautifully show the twinning and complicated intergrowths of the crystals. The feldspar is close to labradorite.

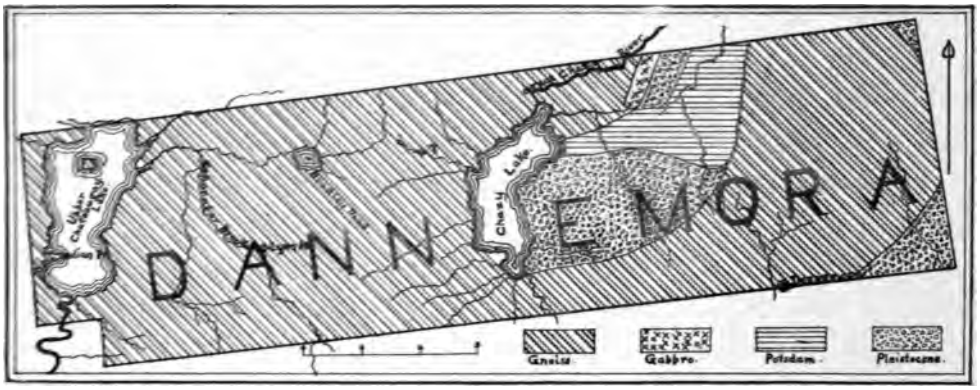
Series VI. The township lies beyond the reach of the Champlain deposits. It has the usual heavy glacial deposits filling the valleys. A long, massive, esker-like ridge forms a conspicuous feature near Ellenburgh depot. It lies right athwart the valley of the English river and has saved the railroad company the trouble of constructing a trestle, or embankment across the valley. It has thrown the river out of its pre-glacial course and must have dammed the valley for a brief time. The river has cut but a narrow trench through it at its north end down to the level of the Potsdam in the stream bed. The summit of the esker rises nearly to the level of the valley walls, the valley being here quite wide and the sides of gentle slope. The length of the esker is not known, but its width is fully one-quarter of a mile. No good sections were seen, but a small cut at the base showed a coarse sand matrix in which pebbles were set, these being somewhat rounded and reaching no great size.

Dannemora.

This township has a more typical Adirondack character than any other in the county, with the exception of Black Brook. The massive ridge of Lyon mountain lies largely in it, though the summit is just over the border in Saranac. The two largest lakes in the county, Chazy and Upper Chateau-

gay lakes, lie, the former wholly, and the latter mainly, within its borders, and the latter is, furthermore, a quite typical Adirondack lake.

Series I. The gneisses constitute the larger part of the township, the massive ridge of Dannemora mountain occupying the eastern portion, Mount Lyon in the centre, and the range of hills which extends into Ellenburgh as Ellenburgh mountain on the west. Much of the gneiss is of the ordinary acid, microperthitic variety, with the ever present bands of basic hornblende gneiss. On Dannemora mountain, along with the red gneiss, is a white gneiss streaked with black, which contains a quite pleochroic green monoclinic pyroxene and much titanite. At Lyon mountain village, the ore-bearing



gneisses are also pyroxenic. They are well foliated, red gneisses, made up of quartz, orthoclase, plagioclase, green pyroxene, deep orange titanite, a little hornblende and magnetite. The pyroxene is strongly pleochroic, like that at Dannemora, a being greenish-yellow, b and c green. The presence of so much titanite in the rocks enclosing the magnetite deposits is interesting. It never appears as rims round the magnetite, as it does in some of the hornblende gneisses.

Series II. Not present in the township so far as known.

Series III. A single small knoll of basic gabbro occurs nearly a mile east of the lower end of Chazy lake, with gneiss in close proximity on the west, and Potsdam on the east, while the gneiss of Dannemora mountain is only two miles away eastward, so that this gabbro is undoubtedly to be classed with the smaller masses which occur interbanded with the gneisses. The rock is somewhat gneissoid, but readily identifiable in the field as gabbro. It is not completely granulated, but of the ophitic type, showing large individuals of labradorite and nearly colorless monoclinic pyroxene of

diallagic habit, both crammed full of intrusions. The interspaces are of granular structure, containing plagioclase and some unstriated feldspar, neither with inclusions; augite, also without inclusions, hypersthene, hornblende, biotite and magnetite. This granular portion has evidently not resulted from the mere granulation of the original rock, but is almost wholly due to recrystallization. Reaction rims of biotite and hornblende around magnetite are excellently shown. Garnet seems to be absent. Throughout the county it is not so characteristic of the basic gabbros as of the northosites, though frequently present in them. Aside from this exposure no rocks of this series have been seen in the township.

Series IV. A tongue of Potsdam sandstone runs into Dannemora, occupying the depression between Dannemora and Ellenburgh mountains, and traceable to Chazy lake, at the Chazy Lake House. Though hemmed in between the gneisses, no coarse conglomerate has been seen, and most of the rock is the red, hematitic, easily decomposing arkose. The best exposures are in Steep Bank brook, two miles north of Dannemora village, and here at an altitude of 1,500± feet, the greatest elevation known to be reached by this rock in the county.

Series V. Forty-one dikes have been found in Dannemora township. Kemp has noted eleven which cut the ore-body in the Chateaugay mine at Lyon mountain, and five more have been described by Eakle from Upper Chateaugay lake. The remainder have been found by the writer. Along the west shore of Upper Chateaugay lake, and along the road north from Dannemora over the mountain, are notable exhibitions of dikes. Four of them are of bostonite, the rest are diabases. Only two of them need further notice here.

Dike No. 46, west of the lower end of Chazy lake is of the bostonite type, but abnormal. It is dark brown to black in color, non-porphyritic, and rather coarse for this rock, with the trachytic structure not well marked. It is almost wholly made up of rather large orthoclases, which are packed full of inclusions of green hornblende and biotite. The two minerals have precisely the same color, so that in many cases it is impossible to distinguish them from one another, but both are present. There are also some larger, irregularly bounded green hornblendes which seem secondary after a nearly colorless monoclinic pyroxene, two cores of which remain in the slide surrounded by the hornblende, which is of the uralite type. It is a curious rock, and if classed with the bostonites, must run very low in silica for that type. Just what was its original condition, is not clear.

Dike No. 66, from Upper Chateaugay lake, is a typical olivine diabase, in which even the olivine is surprisingly fresh. The pyroxene is of lilac color, with quite strong pleochroism, a yellow, b and c lilac. Its phenocrysts are full of inclusions and markedly zonal. In the ground-mass is considerable brown hornblende and some biotite, so that the rock grades toward the camptonites.

Series VI. The Chazy lake valley has some features which suggest fault valley, but the lake is held in place by heavy drift deposits at both ends. There are also heavy drift deposits at the upper end of Upper Chateaugay lake. Bradley pond is but a remnant of a somewhat larger body of water in a wide valley where the drift is unusually heavy, and whose surface is strewn with multitudinous loose blocks of Potsdam. Three miles north of the pond in Ellenburgh, a watershed is formed by an accumulation of hills of modified drift, sand and gravel with surface blocks of Potsdam, which stretches across the valley from side to side.

Saranac.

Series I. Except for the southeastern portion, known locally as Hardscrabble, the entire township is occupied by the gneissic series. The most accessible exposures are those found along the Saranac river, from Saranac hollow westward, the most notable being the section in the gorge below the High falls. Excellent and repeated exposures are also found along True brook. The gneisses in the township are for the most part of the ordinary red, microperthitic variety, with the usual variations in the amount of ferro-magnesian silicates present, and also with the customary bands of basic gneisses, both the hornblende gneisses and the gabbroic gneisses occurring. Along the North Branch of the Saranac, from Petersburgh westward to Cold brook, are microcline and plagioclase gneisses which closely resemble those in Black Brook township already described.

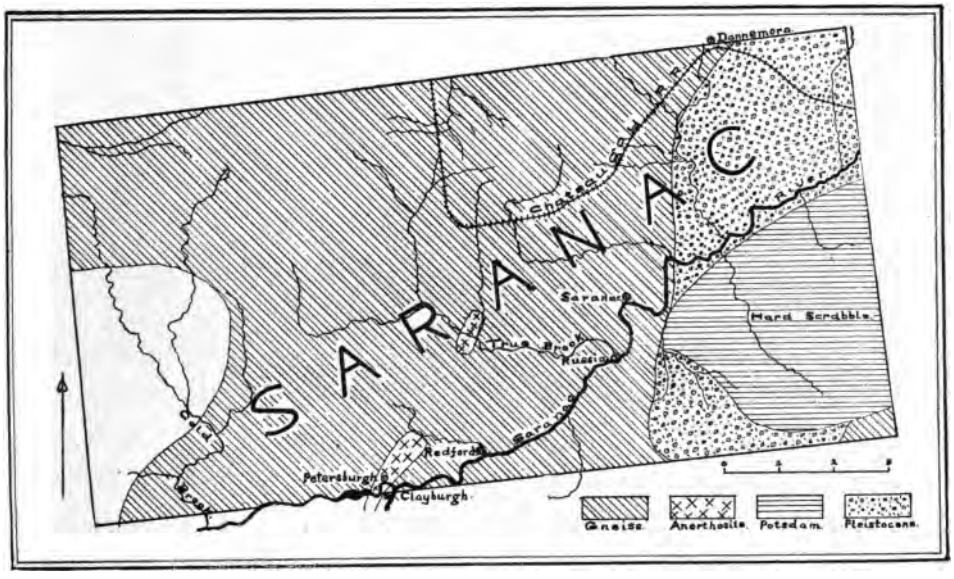
Just east of Russia, north of the road, is a strip of brecciated gneiss, like that described by Kemp from Hammondville and elsewhere in Essex county,* the gneiss being in angular fragments of varying size cemented together by a mixture of chloritic and other decomposition products. The breccia has no great lateral extent and is cut by dike No. 33.

Along True brook, in Lot 35, just above the old mill dams, are scanty exposures of the only rock at all resembling quartzite which has been seen in the county. Unfortunately the exposures are isolated, no others having

* Report of New York State Geologist for 1893, Vol. I., p. 456.

been noted within half a mile to the east, while westward from this point the valley expands, and all rocks are heavily buried in drift. Gneissic ridges are within a mile both to the north and the south, but the rocks accompanying the quartzites in the valley are nowhere exposed. Megascopically, much of the rock is white and granular, with occasional small red garnets showing, and, but for the latter, looking quite like some parts of the Potsdam. Other portions are coarser, showing both quartz and orthoclase, the latter predominating, and with an arrangement of the quartz in leaves, resembling, in that respect, the Canadian rocks which Dr. Adams calls "leaf gneisses."*

Under the microscope, the rock is seen to be mainly composed of microcline and quartz, with some orthoclase, a little plagioclase, and occa-



sional garnets, the whole with a rather finely granular structure. A few larger individuals give the impression that the rock has been granulated, but it is not certain. In one of the two slides made, are found occasional individuals of a nearly colorless mineral, whose parallel extinction, high interference colors, small axial angle, and positive character are indicative of sillimanite, though it is irregularly bounded and somewhat broken and crushed. Its presence is of interest, as the mineral is quite characteristic of certain schists closely associated with the limestones, and may perhaps indicate the presence of the limestone series here concealed by the drift in the valley.

*American Journal of Science, Vol. L., p. 62.

Series III. At Petersburgh, showing well just north of the road, is one of the largest of the basic gabbro bands that has been met with in the county. Measured across the strike the exposure is fifty yards wide, and the full width is not shown, but within a few yards distance, on both sides, ordinary red gneiss comes in. A few yards south of the river at Petersburgh bridge, is a small exposure of similar gabbro, and half way between Russia and Redford, is another with red gneiss close at hand. On the True brook road, just before reaching the fourth bridge (the road crosses the Brook several times), is still another, which looks like an enormous dike ten yards wide, enclosed in the gneiss.

These four gabbros are all alike in mineralogic composition, being made up of augite, hypersthene, hornblende, biotite, magnetite, plagioclase (some untwinned) and apatite. Unlike most of the gabbro of the region, they totally lack garnet. The gabbro south of the river at Petersburgh has the ophitic structure, with the large characteristic feldspars and augites, which always occur when that structure is preserved. The others are all granular, and have suffered recrystallization; that between Russia and Redford having the very finely granular structure of the "shear-zone" rocks. The Petersburgh exposures are readily recognizable in the field as gabbros, while that on True brook more resembles the hornblende gneisses.

Series IV. The Hardscrabble district, a rather elevated plain between the Saranac and Salmon rivers, which lies partly in southeastern Saranac, is occupied by the Potsdam sandstone, but the heavy drift renders it impossible to accurately map its southern, western and northern boundaries. The exposures seldom show more than the upper surface. The rock is thin-bedded for the most part, commonly buff, but with some red layers; is coarse and gritty, but seldom pebbly, and most of it disintegrates quite rapidly, few well indurated layers showing.

Series V. Thirteen dikes have been found in the township, most of which are decomposed diabases. No. 41, just west of the third bridge over True brook, is a typical olivine diabase, with large olivine and augite phenocrysts, the latter of a light rose color and slight pleochroism. The rock is quite fresh, much of the olivine being perfectly sound.

No. 32 is the only bostonite met with. It cuts the gneiss just east of Saranac village, and is a non-porphyritic, dark red rock, which contains a considerable amount of green biotite and of magnetite.

Series VI. The sand deposits of the Saranac valley run up the river to beyond Redford, and are very conspicuous at that point, where they have

an altitude of about 1,000 feet. One mile southwest of Dannemora, at about the same elevation, is a considerable accumulation of sand with streaks of gravel, perched on the valley side about 400 feet above the river, and sand at about the same level shows at several points between. Both here and in the Ausable valley, these delta deposits of the old lake seem to run higher than heretofore recognized.

Black Brook.

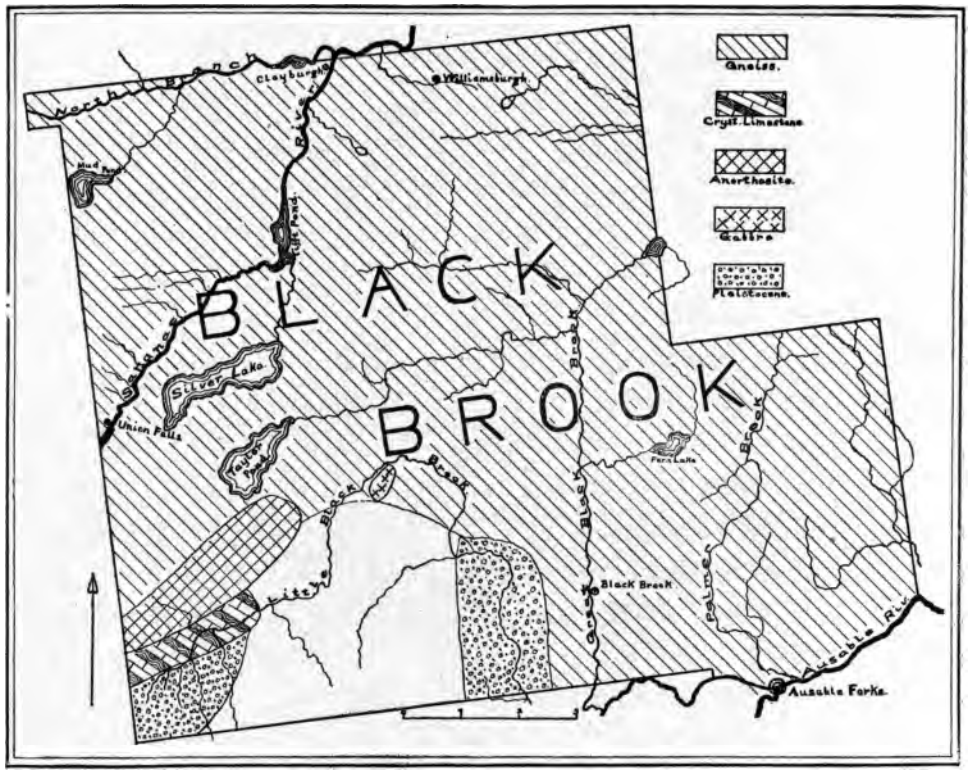
This is the largest township in the county, and lies in the southwestern corner, adjoining Franklin county on the west and Essex on the south. Its western half is wild, and much of it is quite inaccessible. The valleys are wide with few exposures, and the ridges are difficult of access, forest clad, and with their northern slopes heavily drift covered. Hence it is extremely difficult to find outcrops in sufficient number to permit of accurate mapping.

Series I. With the exception of the extreme southwest, the entire township is occupied by gneissic rocks which, for the present, must all be classed together. There is comparatively little of the ordinary microperthitic gneiss. Such is found on the northern border, and on Palmer hill at the east. But even on Palmer hill and along the river at Ausable Forks there is much microcline gneiss, and much of the gneiss contains abundant green monoclinic pyroxene. This association of pyroxenic gneiss with the Palmer hill magnetite deposits is of interest in view of the like association at Mineville, as reported by Kemp.* The same also occurs at Lyon mountain. In some of the Palmer hill gneisses there are titanite rims around the magnetites, a curious circumstance considering their juxtaposition to the ore-bodies. These gneisses are well shown along the railroad just east of Ausable Forks. In these exposures is a sheared strip, three inches wide, in a coarse pegmatitic band, which consists wholly of slickensided chloritic material. Just east of the Forks is a heavy band of basic gneiss, which is hard and firm, and contains, in addition to hornblende, plagioclase, biotite and magnetite, much hypersthene but no monoclinic pyroxene. It is the only rock of the kind seen in the county. The peculiar microcline gneisses, which have been described on a previous page, are widespread in the central part of the township, and the ponderous east and west ridge known as Silver Lake mountain, is wholly composed of them.

At Union Falls, the river drops twenty feet over gneiss and passes northeastward in a gorge, exposing an excellent section in which the very variable

* Report New York State Geologist for 1898, Part I., p. 444.

character of the gneiss, as exhibited in the township, is well shown. The main portion is a well foliated rock of microperthitic microcline and orthoclase, with quartz and a variable, but commonly considerable amount of hornblende, biotite and magnetite. Much basic hornblende gneiss is interbanded with it. A mile and a half a little east of north of the Falls, in a field a few rods back from the road, is a considerable exposure of a brown gneiss which contains an orthorhombic pyroxene of too slight pleochroism and too weak double refraction for hypersthene, and which is probably enstatite. It is the only occurrence of this mineral yet noted in the county.



A short distance to the east is a well foliated microperthitic gneiss holding numerous garnets, a mineral which, as a rule, is quite rare in the gneisses. Gneiss is well exposed for several miles along the valley of Great Black brook, the best exposures being at Black Brook village. This gneiss is, for the most part, a well-foliated plagioclase gneiss, containing also orthoclase, some quartz and a considerable amount of hornblende, biotite and magnetite.

The long ridge called Leggett mountain, which lies in the extreme southwest and extends into Wilmington, Essex county, shows frequent exposures of red and lilac-grey microcline gneiss at its northeastern extremity. Along

with these, is a small outcrop of basic gabbro of the type that occurs interbanded with the gneisses. Exposures elsewhere on the ridge were very difficult of access and were not reached, but it was thought probable that the whole was of gneiss. However, Professor Kemp reports gabbro from the ridge just over the border in Wilmington, and the place where the gneiss ceases and gives way to gabbro must be left for future determination.

Series II. Not far from the Franklin line, in the valley between Catamount and Leggett mountains through which Little Black brook meanders, occur the only exposures of the limestone series which have been found in the county. But three exposures were found, and the extent eastward is uncertain, but the belt passes westward into Franklin county, good exposures occurring around Franklin Falls.

About two miles east of the Franklin line, and lying close up against the side of Catamount mountain, a massive limestone occurs in which a considerable opening has been made and the rock burned for lime. The limestone is coarsely crystalline and much of it quite pure, but other parts contain much green pyroxene, sometimes in great bunches making up the larger part of the rock, sometimes more evenly scattered through the mass. In places graphite and phlogopite occur, but in no great quantity. Locally there is considerable titanite, and there is one finely crystalline, narrow band composed about equally of titanite, pyroxene and calcite. A few small, slender green apatites were noted, but are not common. The breast in the limestone is about twenty feet high and 150 feet long. Not far distant, farther up the ridge, basic gabbro crops out.

By the roadside, some fifty rods south of the limestone, is a small outcrop of a crumbling, rusty gneiss, consisting of a nearly colorless monoclinic pyroxene and microperthitic orthoclase. In addition it contains some sillimanite, titanite and magnetite, quite a little pyrite, and large scales of graphite along the planes of foliation. Associated with it is a band of basic hornblende-plagioclase gneiss. These gneisses are like those associated with the limestone elsewhere and belong to this series. No other outcrop of such gneiss has been seen in the county.

Series III. The massive, northeastwardly trending ridge of Catamount mountain is composed of gabbro, and is probably a prolongation of the area over the border which makes up the Whiteface mountain mass. The two are separated by a wide, drift-filled depression which is probably occupied by the limestone series. The Catamount ridge is suddenly cut off on the southwest, at right angles to the trend of the ridge, and presents in that direction a quite

precipitous face which looks like a fault scarp. Such faces are characteristic of most of the ridges of the county and produce the same impression on the observer as do those of Essex county, which Kemp regards as of the block-tilted type.

The Catamount gabbro is of the anorthosite variety, and so thoroughly granulated that large cleavage faces are seldom visible in the hand specimen. Hence the prevailing color is white, the ferro-magnesian silicates not being in large amount and always concentrated along planes, so that the rock is quite gneissoid. Garnet is present, but not so prominent as in much of the anorthosite. The thin section shows monoclinic pyroxene, hornblende and magnetite.

Not far above the limestone quarry, basic gabbro outcrops, but is so poorly shown that it is impossible to ascertain its extent. It is composed of augite, hypersthene, hornblende, biotite, garnet, magnetite and labradorite. It seems to have been originally of the ophitic type as it contains some of the diallage like augite, full of inclusions, which characterize that type. None of the original idiomorphic feldspar remains, however, and most of the rock seems to have undergone recrystallization. None of the minerals have idiomorphic boundaries except the biotite, which does not appear as reaction rims round the magnetite, but in thin plates distributed through the rock. In fact there is no sign of reaction rims of any kind in the rock. In addition to the above the same gabbroic gneisses are found interbanded with the other gneisses of Series I that are found so commonly in the other townships.

Series IV. No Palaeozoic rocks are to be found in the township although the Potsdam sandstone almost reaches it on the north and east.

Series V. Thirteen dikes have been noted in the township, all of which are diabases. Three of the very narrow ones approach augite-camptonite by the augite of the ground-mass becoming idiomorphic. Nos. 84 and 86 are very typical diabases, furnishing quite fresh material.

Series VI. The higher level of the sand deposits of the Ausable river runs up the river some distance above Ausable Forks, at that point rising some little distance above the river level. Just west of the Forks on the road to Black Brook an excellent section, twelve feet in height, is exposed, which is as follows, from the top downward:

1. Soil.
2. Coarse yellow sand with a few boulders, ... 2 feet
3. Fine white sand with no boulders, ... 3 "
4. Stiff, blue, jointed clay, weathering white, . . . 1 "

5. Sandy, laminated clay, somewhat undulating, . . 0 feet 9 inches.

6. Laminated, clayey sand, much folded and contorted, 1 foot.

7. Alternating thin bands of sand and clay with occasional rounded boulders, to the base of the section, with a six-inch clay seam in its upper part, which unites with the upper jointed clay, No. 4, at the west end of the section, but one hundred feet away is three feet below it. At the east end everything is cut off by the sudden downward dip of the upper yellow sand. The white sand, No. 3, contains thin streaks of fine gravel and occasional small clay nodules, and becomes very gravelly at the east end of the cut. The whole seems clearly a shore deposit in standing water.

Ausable.

This is the smallest of the townships, and lies in the southeast, with the Ausable river forming its southern boundary except at the extreme east, where a narrow strip of low sandy land belonging to the modern delta of the river is included in the county.

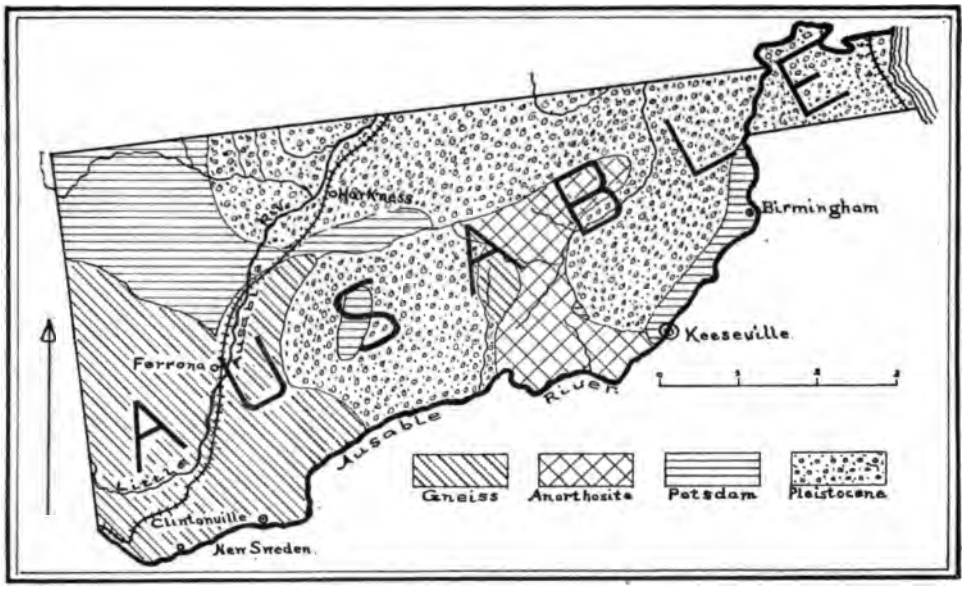
Series I. The gneisses cross the river into the county at Clintonville and continue thence northeastward about half-way across the township, when they are overlapped and indented by the Potsdam, their line of outcrop swerving to the west and then to the northwest. The wide gneissic hill in the western part of the township is known as Arnold hill, and is topographically an extension of Palmer hill in Black Brook. The Little Ausable river cuts through it in a narrow, steep-sided valley, apparently due to a fault, with the gneiss showing grandly on the east side. At Clintonville and northeastward from it, are also excellent exposures. Then follows a drift filled depression a mile in width, beyond which the gneiss again crops out in two low hills, round which the gabbro sweeps in a semi-circle.

The exposures are, for the most part, of ordinary microperthitic gneiss, with some plagioclase gneiss toward the north, and with the usual bands of hornblende gneiss. On Arnold hill are important ore-bodies. About one mile southwest of Harkness station and near the railroad, is a strip of no great width which resembles a dike and is probably a sheared strip. It is a finely granular black rock, made up of plagioclase, orthoclase, hornblende, biotite and magnetite, hence with the mineralogy of the hornblende gneisses.

Series III. Lying east of the gneisses, and forming the rather low elevation known as Halleck's hill, is an area of anorthosite. It has a breadth

of one mile and a half where it crosses the river from Chesterfield, and gradually decreases in width going north till the last of it runs under cover two miles north of Keeseville.

The district furnishes the most typical anorthosite to be found in the county. While the rock is much granulated, some of it wholly so, there is still much of it that shows partially unbroken crystals of labradorite that reach, on occasion, a very considerable size, being found up to three inches in length. A considerable part of the rock is almost wholly feldspathic, the ferro-magnesian minerals occurring only in very small amount. The less feldspathic portions of the rock are the most completely granulated, and have a prevailing gneissic habit. In these varieties garnet is very abundant, often



imparting a reddish tint to the rock. In them reaction rims are also a feature, and a considerable amount of recrystallization has taken place. Openings have been made in the more feldspathic portions of the rock in the vicinity of Keeseville, and some of it put on the market under the name of "Keeseville granite." It makes a very handsome stone, the large, blue-grey labradorite crystals surrounded by a lighter colored granulated zone giving a very pretty effect; but no tests of its crushing strength have been made, so far as the writer is aware. It seems quite resistant to weathering.

In several places in this anorthosite area are found bands of basic gabbro. When finely granular, as is commonly the case with the thinner bands, they look like dikes. The larger masses are often less changed and

show the rude ophitic structure already described. The larger feldspars often show beautiful pressure effects, the crystals not only being broken but frequently bent. In one slide is a well-twinned crystal, about seven millimetres long, in which the gradual variation in extinction from one end of the crystal to the other amounts to 25°, showing a bending to that amount, yet with no apparent breakage of the crystal.

The contacts between these basic bands and the anorthosite are often as sharp and clear as intrusive contacts, so that slides may readily be prepared consisting half of one and half of the other.

As has been already stated, these basic gabbros are so absolutely like the basic gabbroic bands found in the gneisses, that there can be no question as to the identity of the two. Neither in the hand specimen nor in thin section can they be distinguished from each other. Both the granular and the ophitic phases occur in both situations. It would seem most probable that they are to be regarded as basic segregations from the main anorthosite intrusion, which have been stretched out into bands parallel with the foliation of the enclosing rock as a result of dynamic metamorphism. Such segregation would take place mostly toward the periphery of the mass, and such portions as were squeezed out into cracks in the enclosing rocks would be mainly of this type. But on the other hand the frequent sharp boundaries between the basic gabbro and the anorthosite, with no sign of gradation into each other, and the much wider distribution of the gabbro, can not but give rise to the suspicion that, at least in part, the gabbro intrusion may have been subsequent to that of the anorthosite.*

A massive band of basic gabbro which is found in the anorthosite at a point a little over a mile west of Keeseville, just north of the river road, is interesting as showing a gradation toward diorite. Monoclinic pyroxene and garnet are found in the rock but are very subordinate to the hornblende, which shows great development, while hypersthene is absent. A hint of this is given in the appearance of the rock, which is more schistose than the normal gabbro. The main interest attaching to the occurrence is from its possible bearing on the origin of the hornblende gneisses of the gneiss series, which the rock much resembles.

Two miles west of Keeseville, on the river bank, is a knob of gabbro which is interesting as indicating a transition to gneiss. It is of brown color, finely granular, and contains quite a little quartz and microperthitic

* Later work by both Professor Kemp and the writer demonstrates that much, if not all of the basic gabbro is of later date than the anorthosite, as indicated here at Keeseville.

orthoclase in addition to the ordinary gabbro minerals, plagioclase hornblende, augite, garnet and apatite. It is the most westerly of the gabbro outcrops, but two miles of barren ground intervene between it and the Clintonville gneisses.

Series IV. The only Palaeozoic rocks exposed in the township are of Potsdam sandstone. The magnificent exhibition of this rock in the Ausable chasm has been mentioned by many observers, and has been carefully measured by Mr. Walcott.* Except for this river section, all the Potsdam in the eastern part of the township is deeply buried by sand. The rock exposed at Keeseville and in the chasm is quite homogeneous, of white, grey or yellow brown color, and the fossils indicate that it is the upper portion of the formation that is here shown. This, together with the lack of red beds and conglomerates as the gabbro is approached, gives rise to the suspicion of a fault contact. It is about on a line, also, with a fault which runs through Peru and Plattsburgh, close to the lake shore.

A very interesting exposure of Potsdam on the west side of the supposed fault is worthy of description. The locality is not quite a mile west of Keeseville, not far west of the race track, and a few hundred yards southeast of School No. 5. Nestling in an indentation in the eastern face of the gabbro is a small mass of peculiar, very coarse conglomerate, capped by very red thin-bedded layers of feldspathic sandstone of the ordinary basal type. The conglomerate carries very numerous, well-rounded quartz pebbles of a reddish lilac tint, ranging in size up to two inches in diameter. With these are occasional smaller fragments of orthoclase and a few dark colored pebbles of decomposed rock, apparently of diabase. In streaks magnetite is present in very large quantity, in well rounded grains. The coarsely granular matrix looks black when fresh, but on weathering becomes mottled with blotches of green chloritic material, which gives the predominant color to the rock. In thin section, grains of quartz, microperthitic orthoclase, magnetite, titanite and microcline, named in order of abundance, are seen to constitute the matrix, and are set in a green chloritic-like cement, whose exact nature is not clear. The coarseness of the conglomerate is astonishing when we remember that it is composed entirely of gneissic debris, yet is in contact with anorthosite, the nearest exposures of gneiss being one mile and a half away.

In the northern and western parts of the township considerable Potsdam is exposed. It is, for the most part, a hard, flinty sandstone of buff color,

* Bulletin 81, United States Geological Survey, pp. 343-344. The boss of granite mentioned by Mr. Walcott, on the river bank above Keeseville, is of gabbro.

though on the north flank of Arnold hill, in the vicinity of the gneiss, coarse conglomerates occur. In the central part of the town it runs down in a curious way between two gneiss ridges. There is here a drift-filled valley, a mile or more in width, which runs clear across the township, and was apparently the track of a pre-glacial stream. Along the Ausable it intervenes between the Clintonville gneiss and the gabbro to the eastward, but further north, gneiss ridges form both walls. At the north end, the Potsdam-gneiss contact is found near Mr. Harkness's house. The well on the premises, close by the house, penetrated hornblende gneiss at a depth of a few feet, while only five rods to the northwest, flinty Potsdam was reached in a cistern. One mile and a half to the southward, are two old openings in Potsdam sandstone, known as Mace's quarry. The rock is ordinary hard, massive, buff sandstone. Less than a mile away on each side, are massive gneiss ridges, and we have here apparently a pre-Potsdam as well as a pre-glacial valley. It is unfortunate that the drift covering does not permit us to determine how far up this valley the Potsdam runs, but there seems no reason why it may not run clear to the Ausable river. It recalls the patches of Potsdam described by Kemp from Essex county.*

Series VI. The northern slopes of Arnold hill are covered with till, and the surface is plentifully besprinkled with boulders. The till covering ranges throughout the gneissic area, but elsewhere in the township everything of the sort is hidden from sight beneath the universal mantle of sand. This surrounds Halleck hill on the east and north, running clear to the lake shore and well into Peru. It extends up the Ausable valley beyond the limits of the township, and at Clintonville and New Sweden is heavily banked up against the gneisses, is bare and much drifted about by the winds. It also extends throughout the valley of the Little Ausable, even in its narrow upper reaches, great drifts of it lying around and against the protruding bosses of gneiss.

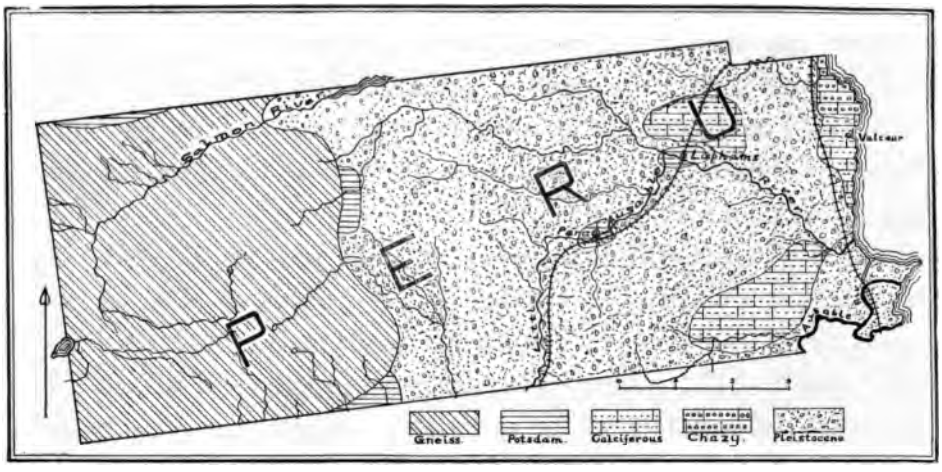
Peru.

The western third of Peru township is hilly, and occupied by the gneisses. A plain of till, with a breadth of one mile and a half, borders the hills on the east. Then there is a drop of fifty to one hundred feet, to the level of a sand plain, which has a breadth of from three to four miles. For the last three miles to the lake, rock ledges protrude frequently through the

* Report of New York State Geologist for 1893, Vol. I., pp. 454-458.

Champlain clays and sands, but from thence westward to the hills everything is concealed by the drift and sand.

Series I. Three northeasterly trending gneissic ridges rise in the western third of the township. The most northerly of these is a narrow ridge known as Burnt hill, which rises rather abruptly from the Salmon river valley, but whose summit is only a little above the level of a plain of Potsdam sandstone, which overlaps it on the north. In the central-west is the wide, massive ridge of Terry mountain, and to the south is a somewhat disconnected ridge coming in from Black Brook, the most easterly summit of which is called Mt. Etna. The larger part of the gneiss is of the ordinary microperthitic variety. A quite prominent gneiss on Mt. Etna is a quartz plagioclase gneiss, with some microcline and orthoclase, and with hornblende, biotite and magne-



tite present in considerable amount, so that the rock is well foliated. The Burnt hill gneiss contains much microcline, that mineral often constituting more than fifty per cent. of the rock.

Series II and *III* do not appear in the township.

Series IV. Potsdam sandstone. Though the Potsdam must occupy much of the central part of the township, the exposures, with one exception, are close to the gneiss, poor, and possess no special interest. At Lapham's mills the Little Ausable is in a new channel, and about thirty feet of Potsdam is there exposed, all rather coarse, some of it red, but mostly buff or brown in color. The dip is to the southwest, and rocks of Calciferous age surround it on all sides. That in the river bed at Peru, one mile to the southwest, has the same dip, while the exposures to the north and east dip to the northeast, and a fault must lie between them and the Potsdam, this fault being probably along the summit of a low fold.

Calciferous sandrock. Rocks of Calciferous age apparently form the surface over most of the eastern third of the township, although no certainty can be reached upon this point, due to the scarcity of exposures. The outcrops are small and isolated, and generally give no clew to their horizon in the Calciferous, being for the most part of the iron-grey dolomite which constitutes such a large part of the formation. Just north of Lapham's, are meagre outcrops of very sandy dolomites, which weather to deep ferruginous, sandy, brown crusts, and seem to belong to Division D, of Brainard and Seely.

Along the lake shore, both north and south of Valcour, rocks of this age outcrop for a distance of a mile or more. The major part of the rock is a hard grey dolomite, full of seams and balls of calcite, and in some layers quite fossiliferous. Interstratified with them are thin bands of limestone, more abundant toward the top. Here limestone is also found in irregular lenses, which are full of fragmentary fossils, looking as if they had been worn on a beach. An *Ophileta*-like form also occurs, and is the only species found entire. The rocks lie in a series of low east and west folds, with a slight fall of the whole toward the north. They are well toward the top of the Calciferous, and are followed a short distance to the north, apparently conformably, by the lower Chazy. The whole mass is penetrated by irregular slaty seams.

Chazy limestone. From Valcour northward along the lake shore, rocks of Chazy age outcrop in a belt about half a mile wide, abruptly terminating on the west along a fault line, the Bluff Point fault. The exposures are rather infrequent, and the district needs detailed study, but everything seen seems referable to the lower part of Division A, of the Chazy. On Mr. Day's land two quarries have been opened in the rock, one near his house and one by the lake. In the upper quarry especially, the rock is quite fossiliferous, and good collections can be made. A large *Nautilus* is conspicuous among the fossils. Mr. Day has an excellent *Lituites* obtained from the quarry. Trilobite fragments abound, mainly of *Illœnus* and *Harpes*, and several species of brachiopods are present, *Orthis costalis* being the most common form. The locality is one of considerable palaeontologic interest.

Series V. Eight dikes have been found in Peru, of which six are diabases, and call for no special mention. The other two cut the Chazy limestone, near the lake shore, and are of interest on account of the rarity of dikes in the county outside of the pre-Cambrian rocks.

No. 2, in the field just south of the Day quarry, is a typical camptonite, the only one so far found in the county. It may be traced clear to the lake

shore, a distance of some 600 yards. Unfortunately it does not furnish very fresh material.

No. 3 lies one-fourth of a mile south of the other, and is a beautiful monchiquite. Material may be obtained in which even the olivine is quite fresh. The strike of this dike would carry it over to the southern part of Valcour Island, and it may be the same dike as the one found there by Brainard and Seely. As far as can be told from the description, the two are quite similar. But in so disturbed a region such identifications are extremely hazardous.

Schuyler Falls.

There is little of interest in the geology of this township. The extreme eastern edge of the Burnt hill gneiss comes into the southwestern corner from Peru. With this exception the only rock exposed in the township is the Potsdam sandstone, though it is reasonably certain that the Calciferous is also present in the east, obscured by the heavy sand. The western part of the township is occupied by Potsdam, lying at a tolerably high level, and continuous on the west with the Hardscrabble Potsdam in Saranac. The gorge of the Saranac river, at Cadyville, is cut in the eastern edge of this plateau, and exposes an excellent section. The old channel of the river lies to the northward and is filled to the brim with drift. Along the Salmon river the rock is well exposed at Schuyler Falls village, and less well at Norrisville. In the exposures is much red rock, and some that is tolerably coarse, but whether low or high up in the formation does not appear.

Series VI. All the eastern half of the township is heavily covered with sand, the level ranging from 300 to 400 feet altitude. Occasional cuts show the clay below. Further to the west the prevailing cover is still sand, though at higher level, and becoming more and more confined to the vicinity of the river. Along the Chateaugay railroad the sand shows grandly, much of it being bare and forming dune-like ridges. Cuts in the river bank at Morrisonville show an esker-like deposit of coarse sand and gravel, with small somewhat rounded boulders. Its summit lacks a few feet of reaching the level of the sand plain, so that its presence would be unsuspected were it not for the river channel.* A precisely similar section is shown along the Salmon river just west of Schuyler Falls, which may represent a prolongation of the same deposit.

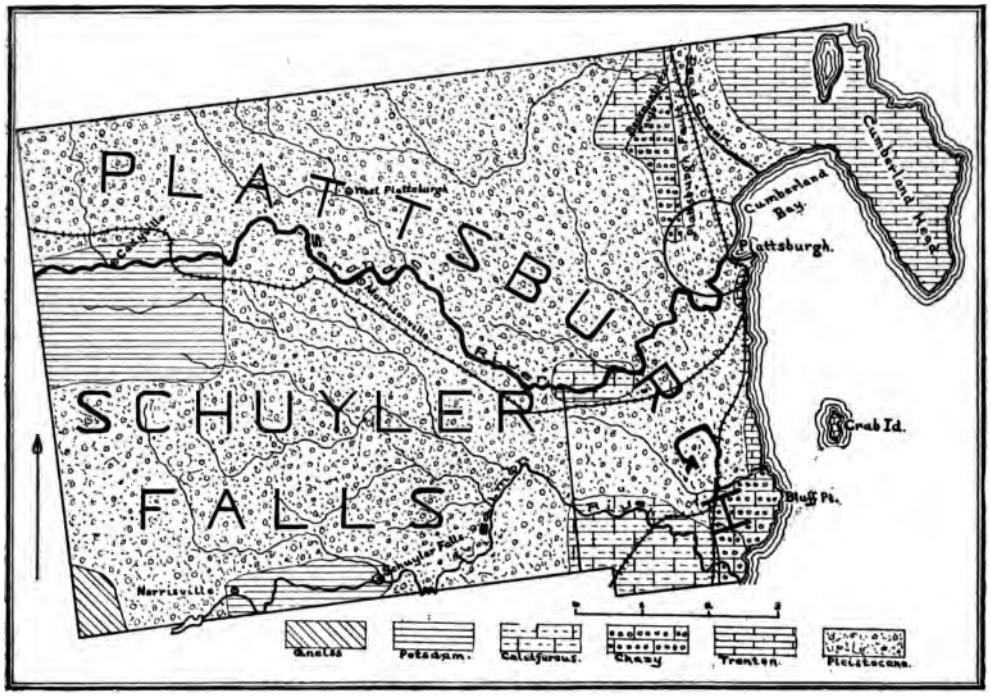
* This esker (?) is noted by Mr. Baldwin in *American Geologist*, March, 1894, page 177.

Plattsburgh.

No pre-Cambrian rocks occur in Plattsburgh.

Series IV. Potsdam sandstone. Except for the river exposures at Cadyville just alluded to, the Potsdam does not outcrop in the township. In fact, with this exception there is not an outcrop of any kind in the western three-fourths of Plattsburgh. This wide belt must be underlaid in part by rocks of Potsdam, in part by those of Calciferous age; but where the boundary between them may lie is purely a matter of assumption.

Calciferous sandrock. By the Salmon river, at the bridge two miles above the mouth, several ledges of a hard, dark blue, somewhat calcareous



dolomite are exposed. By the road south of the river a grey dolomite, with seams and spheroids of calcite, is shown. Though no fossils were found, the lithology of these outcrops puts them in the Calciferous, probably well toward the top.

At the pulp mill on the Saranac, three and one-half miles southwest of Plattsburgh, the river is out of its old channel for a short distance, and exposes a vertical section of some fifty feet, showing heavy, dark blue-grey dolomites, which hold spheroids of calcite, and weather to a yellow color, interstratified with dark calcarous slates. No fossils were found, and no other

exposures are near, to aid in determining the horizon, which is regarded as Calciferous, though with some hesitation, it being possible that the rock belongs at the base of the Chazy.

Along the road to Beekmantown Corners, north of Plattsburgh, a long ridge of rock of Calciferous age is exposed, mainly of a flinty, grey dolomite in massive beds lying nearly horizontal. In the bed of Kennon brook, nearly to the Beekmantown line is a considerable exposure, exhibiting some twenty feet of rock, the lower part consisting of dark blue, sparkling dolomites mingled with lighter colored, more sandy beds and thin layers of white, hard sandstone, while above are massive iron-grey dolomites. These beds are well down in the Calciferous, higher layers coming in above them in Beekmantown.

Chazy limestone. The Chazy is excellently exposed on, and southward from Bluff Point, and also north of Plattsburgh, where it lies just to the east of the Calciferous exposures described above.

Brainard and Seeley have written briefly of the Bluff Point exposures.* The point is a conspicuous topographic feature, rising sharply to an altitude of 170 feet above the lake, and being the only high ground along the shore in the entire county. It is a fault block with a resistant stratum at its summit. Nearly the whole of the middle Chazy and about one hundred feet of the lower division are well exposed. By following along the ridge southward from the point, into Peru, nearly the whole lower division may be brought into the section. The whole series is characteristically fossiliferous. Along the lake shore at the boat landing, the beds shown are well up in the *Maclurea* division, are much jointed, and contain abundantly a large strophomenoid form, much like *R. alternata*, of the Trenton, for which it was taken until the discovery of *Maclurea* threw doubt upon the identification. Several other species may also be collected there.

Just south of Bluff Point is a large quarry, worked in a layer of the lower division in which the crinoidal fragments have a red color. Much stone has been, and is being taken out, which, when polished, makes a beautiful and striking marble.

The Chazy north of Plattsburgh is in a much faulted district, and has been mapped in detail.† At the normal school, beds of lower Chazy age are exposed, which crop out again going north, and are then succeeded, just beyond the race track, by the lower *Maclurea* beds. These continue along the road for a distance of nearly a mile, with a sinuous strike. They consist mainly of massive, nearly black limestones, and are largely quarried. With

* Bulletin Geological Society of America, Vol. II., p. 295.

† See map, p. 556

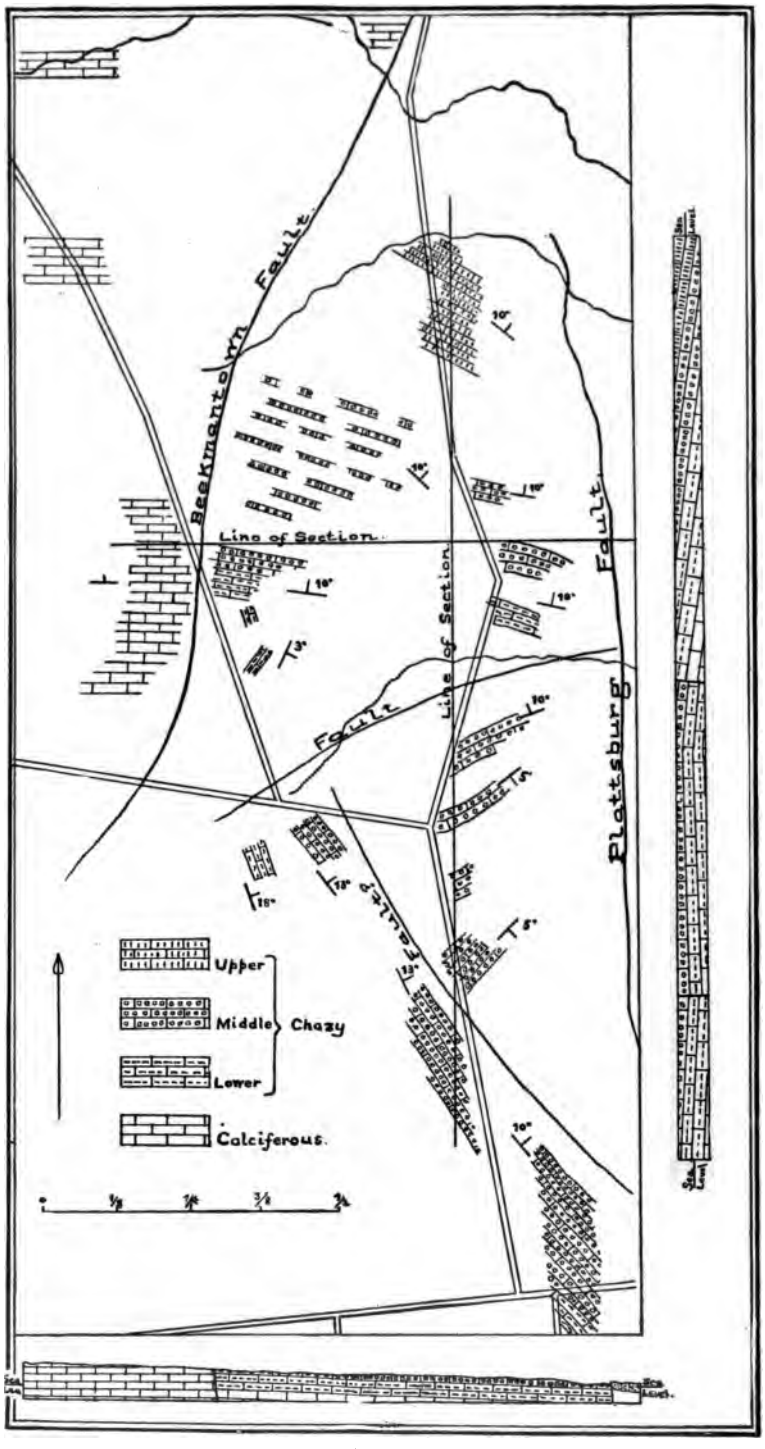
these are thin-bedded, rather shaly bands, with an abundant brachiopod fauna. Just beyond the three corners, a little over a mile north of Plattsburgh, is an east and west fault, bringing up again the upper beds of the lower division on the north side. This is followed at once by the *Maclurea* beds again, and thence northward the entire *Maclurea* division and a large part of the upper Chazy appear within the space of a mile, the latter well exposed and abundantly fossiliferous. The final exposures are less than half a mile from the Beekmantown line, and are succeeded, in the direction of dip, just across that line by massive dolomites of Calciferous age. If the section of the Chazy here be combined with the Bluff Point section, a nearly complete exhibit of that formation is obtained.

Trenton limestone. The best exposures of the Trenton to be found in the county are in this township, but the base, the Black River limestone, is nowhere exposed. Along the lake shore, just south of Bluff Point, and extending for a third of a mile, are beds of Trenton age. They are separated from the Bluff Point Chazy by an east and west fault, with a throw to the north of about 200 feet. A small stream occupies the fault line. The section exposes some 100 feet of the Trenton. At the south end the dip is steep, the beds being tipped up along the fault. The rock is, for the most part, a black slaty limestone with lighter colored limestone bands toward the base, which contain the brachiopod fauna characterizing the lower 100 feet of the Trenton in Chazy township. The upper two-thirds of the section is quite barren of fossils, occasional trilobite fragments occurring. Similar beds are found in the same position on Crab island, which lies one mile to the eastward. The section there has already been briefly described. The island is structurally a low anticlinal fold, pitching to the north about five degrees. The upper 100 feet of rock exposed there, carrying a lamellibranch fauna, is shown nowhere else in the county.

On Cumberland head, and thence northward into Beekmantown, are the slaty exposures already described. They are younger than any of the Crab island Trenton, and separated from that by an unknown vertical interval. Just south of the breakwater at Plattsburgh, similar slates are exposed on the shore, in which no fossils have been found, but in which thorough search should be made, as they may be found to partially fill this gap. Lithologically they resemble the Cumberland head series much more than they do the ordinary Trenton.

Faults in Series IV. The whole Palaeozoic series is greatly faulted. Though much remains to be done in working out the faults, especially the

minor ones, the greater breaks stand out prominently, and deserve mention. The Bluff Point Chazy is cut off sharply on the west by a north and south



fault of considerable extent and magnitude. In southern Plattsburgh, however, no rock shows to the west of the fault line. It may be traced to

the south into Peru, and well to the north also. We may call it the "Plattsburgh fault." Just north of Bluff Point, the east and west fault, already described, runs out to meet it. The throw of this, which may be called the "Bluff Point fault," is to the north, and an approximation to its amount may be had. The entire upper division of the Chazy, 200 feet thick on Valcour island, fifty to 100 feet of the middle division, and fifty to 150 feet of the Trenton are missing, so that the vertical displacement is from 300 to 400 feet. North of this fault, the Plattsburgh fault is not traceable for nearly four miles, on account of the total lack of exposures, but north of Plattsburgh city, on the prolongation of the fault line, is a displacement which is thought to be the same. Here the Chazy exposures on the west side are sharply cut off at an angle with their strike. To the east no rock is exposed for a distance of one mile and a half, when the Cumberland head slates come in. Though the fault line is strongly marked wherever shown, no data are available for determining the amount of displacement. The throw is to the east, and must be large.

Three-fourths of a mile to the west is another great fault, very well shown, which brings up the Calciferous against the Chazy. The horizon in the Calciferous has not been determined, but is apparently well down, so that the entire lower division of the Chazy, over 300 feet thick, and probably a much greater amount of the Calciferous, are faulted out, the throw again being to the east. This fault may be named the "Beekmantown fault." It has a more easterly trend than the Plattsburgh fault, so that the two appear to effect a junction on the Beekmantown line, shutting out the Chazy altogether, and bringing the Calciferous and Cumberland head series into contact in southern Beekmantown. The displacement here, therefore, must be very great, as the entire Chazy, all the ordinary Trenton, and an unknown amount of the Calciferous are missing, and 1,500 feet would be a very moderate estimate of its amount.

These three, together with the cross-fault in the Chazy beds between the Plattsburgh and Beekmantown faults, are the main faults in the township. Small faults occur on Cumberland head, and the slaty cleavage there developed in the whole series would probably be represented by a considerable fault, were the beds more rigid. No doubt other faults occur, but the paucity of outcrops renders their discovery and decipherment nearly impossible.

Series V. Only two dikes have been found in the township, but they are of interest as, together with the South Hero dikes described by Kemp,

they are the most northerly of the post-Utica basic dikes known along the lake Champlain meridian.

Dike No. 1 is exposed by the roadside on the road south from Plattsburgh, a few yards beyond the point where it rises from the sand plain on to the Bluff Point limestone exposures. It is a quite typical monchiquite, with very abundant olivine phenocrysts, often perfectly fresh, which speck the dense black rock with white spots. Occasional small porphyritic augites also occur. The dike being so narrow, the ground-mass is very dense throughout, and consists of small, slender augites, magnetite and sparse brown hornblendes set in an apparent glassy base, most, if not all of which has a very weak double refraction, and thorough investigation may show the presence of analcite.

Dike No. 4 cuts the Trenton north of Bluff Point, and is near the south end of the section. It is largely made up of a nearly colorless augite, which occurs in two generations, phenocrysts, however, being only occasional. Olivine is present, but rare, and can not be regarded as an essential constituent. Hornblende is absent except for a few green, uralitic crystals of secondary origin. Magnetite is present in considerable amount, and there is also a notable quantity of biotite in the ground-mass, some of which is certainly primary. The rock contains numerous round white spots, giving it an amygdaloidal appearance. In the centre of the dike is a strip six inches wide which is clearly marked off from the rest, runs the whole length of the dike, and gives the impression of a second dike cutting the first. The rock is of the same character, however, though the white spots are less abundant than in the main dike. Under the microscope these white spheroids are seen to be formed of a colorless, isotropic mineral, which by means of a gypsum plate, is seen to be optically anomalous, in that it shows faint double refraction. The mineral seems to be analcite. Some of the spheroids contain also calcite crystals. Inclusions of biotite, apatite and hornblende, of rather large size, occur in the analcite. The spheroids are not sharply bounded, but grade into the rock. Considerable analcite is also present in the ground-mass of the rock.*

Dike No. 19, from Crab island, is quite similar. It is made up of augite, biotite and magnetite, with glassy base, but it lacks the analcite spheroids, and instead is amygdaloidal, the cavities being filled with calcite and zeolites other than analcite. It has numerous and large porphyritic augites.

* Since the above was transmitted for publication, the article published by Professor L. V. Pirsson "On the Monchiquite or Analcite Group of Igneous Rocks" has appeared (Journal of Geology, Vol IV., p. 679). Pirsson shows the presence of analcite to be a feature of these rocks. The analcite in Dike No. 4 seems to be primary.

Series VI. The widespread sand deposits of the Saranac, form here, as in Schuyler Falls, the most conspicuous feature of the Pleistocene deposits. Away from the river in the northwestern part of the town, heavy morainic deposits come in above the level of the sand plain.

Beekmantown.

Series I to *III.* The only Pre-Cambrian outcrop in Beekmantown is found on Rand's hill, a wide northeast and southwest ridge running from western Beekmantown into southern Altona. On the east and south, a heavy mantle of drift covers the flanks of the hill, concealing the extent of the rocks in those directions. The ridge is made up, for the most part, of anorthosite which is flanked on both sides by gneiss. On the east is a microperthitic gneiss of brown color, which contains both green monoclinic pyroxene and hornblende. On the west the only gneisses shown are basic, very schistose hornblende gneisses, both with and without pyroxene.

The main interest attaching to the anorthosite here is due, in the first place, to its distance from the main body of that rock; and, in the second place, from the information it gives regarding the character of the surface on which the Potsdam was deposited. At the present time the hill is entirely surrounded by Potsdam, with the possible exception of a strip half a mile wide. The summit has an elevation of 1,500 feet, while the Potsdam on the west side runs up to 1,400 feet, and we are certainly justified in assuming that at one time the whole hill must have been covered by the sandstone, quite probably to a considerable depth.

The exposures of the anorthosite in Beekmantown are by no means as good as in Altona, and the rock will be described in the report on that township. Those in Beekmantown are of quite typical anorthosite, but the rock is not fresh.

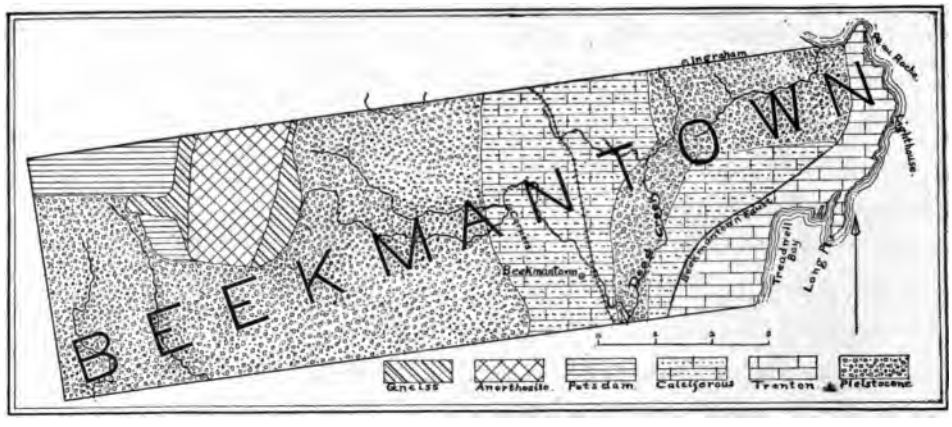
Series IV. Potsdam sandstone. The only outcrops of this rock seen in the township are along the road over Rand hill, and closely adjoin the anorthosite on the west. The exposures are tolerably frequent, but very poor and the only rock seen is of the red, feldspathic, easily disintegrating variety. Except for a gap one-half mile wide, occupied by hornblende gneisses, the Potsdam exposures are practically continuous along the west side of the anorthosites, and the road is reddened throughout the larger part of its length, by the degraded rock. No conglomerates were seen.

East of Rand hill, the very heavy drift-covering completely hides all rock from view till the Calciferous exposures in the central part of the town

are reached. To the south, too, everything is concealed. Much of this covered territory must be occupied by the Potsdam.

Calciferous sandrock. This formation is better shown as a whole in Beekmantown than anywhere else in the county. In the central portion of the town, within a radius of two miles from Beekmantown Corners, are many exposures, the aggregate thickness of which must be very great. One mile north of Beekmantown station, is the fossiliferous locality which has been described by Professor Whitfield,* where beautiful Ophiletas may be obtained in abundance. The other exposures are of very sandy grey dolomites, sometimes passing into nearly pure white sandstone. All the Calciferous here seems to belong to Divisions C and D, of Brainard and Seely.†

Southward from Beekmantown village, a well marked ridge of Calciferous dolomites runs southward, and is continuous with the Calciferous



that lies west of the Beekmantown fault in Plattsburgh. The best exposures are at the Poor-house. The fault passes into this township, but its course has not been definitely traced.

Exposures along the Lake. Cumberland Head Series. The black slaty limestones of this series extend into the township from Plattsburgh, and are exposed along the shore of Treadwell bay and thence westward for a mile. The exposures form a series of narrow, sharp ridges, the topography resulting rather from the slaty cleavage than from the dip of the rocks. The fossils are the same as on Cumberland head.

On the shore at Long point and to the northward, are similar rocks. They have so far furnished no fossils, and require further study, but are classed with the preceding provisionally, on account of the lithologic and

* Bulletin American Museum Natural History, Vol. III., p. 2.
† Bulletin American Museum Natural History, Vol. II., p. 48.

topographic similarity. They lie well to the eastward of the Treadwell bay exposures, as though shifted by a fault. If that be not the case, they are at a higher horizon.

Rocks of Uncertain Age. Closely adjoining these Cumberland head slates on the west, are hard, grey dolomites, which form occasional knolls protruding above the general surface. In one of the exposures, limestone bands occur, which are full of fossil fragments, and similar to the bands described from the upper Calciferous in Peru, just north of Valcour. These rocks would be unhesitatingly classed as Calciferous, were it not for their position. It seems certain that they must belong to that group, and they are so represented on the map. Yet they are separated from the main exposures of the Calciferous in central Beekmantown by a wide valley in which no exposures occur, while the topography gives no indication of a fault between them and rocks close at hand on the east, which lie at least 1,500, and probably 2,000 or more feet higher in the section. This may be the line of the Beekmantown fault. It is at least certain that throughout this territory the entire Chazy is faulted out.

Along the lake shore, from the extreme end of Point au Roches, southward to the lighthouse, are pretty continuous exposures of blue and black limestones, at times somewhat slaty, but ordinarily massive. They are very barren of fossils, holding *Leperditia* in some layers but little else, so far as found. The top layer at the Point is charged with marcasite and contains *Leperditia* and a *Holopea*-like gasteropod, abundantly. The section has considerable thickness; just how much, remains to be determined, but one hundred feet is a very modest estimate. The writer is unable at present to indicate the precise stratigraphic position of these rocks. Mr. Van Ingen writes that the *Leperditia* layer at the Point recalls the basal bed of the Black River limestone on Button Bay island, and is disposed to correlate it with that, and to regard all the rest as of Chazy age. While this is quite probably the proper interpretation, the entire lack (or apparent lack) of the fossils which elsewhere in the county abound in most of the upper Chazy, is an objection to it. The rock closely resembles some beds found in the upper Chazy, but they nowhere exhibit anything like the thickness shown here. It is therefore thought that we may here have beds of Trenton age not met with elsewhere in the county, occupying a position either just above, or just below the Cumberland head series, and they are provisionally indicated as such on the map. If they are of Chazy age there must be a considerable fault between them and the Trenton slaty limestones north of Long point.

Such indecisive results are presented very apologetically. The scarcity of fossils and the lack of time for work of the detailed character necessary are accountable therefor.

Series V. The eight dikes found in Beekmantown, are all on Rand hill, cutting the Pre-Cambrian rocks. The proportion of bostonites is greater than usual, six of the dikes being of that type. These show well the very considerable variation which such rocks present. Dikes Nos. 28 and 29 are of dense, hard red rock of aphanitic, stony look, almost entirely devoid of phenocrysts, and with very small content of ferro-magnesian silicates. Nos. 27 and 107 have a peculiar schistose appearance in the hand specimen, as if they had been subjected to shear, but the appearance is entirely lost in the thin section, which appears quite normal. They contain a larger proportion of dark silicates than the first two. No. 27 has also abundant orthoclase phenocrysts of unusual purplish color, which is due to the filling of the cleavage cracks by hematite.

Nos. 31 and 103 are nearly black rocks, likely to be taken for diabases in the field unless carefully inspected, but in the slide are quite like the others except for the presence of a much greater amount of hornblende and biotite. These occur mainly as inclusions in the orthoclase, and the trachytic structure is not well defined.

Series VI. Rand hill is so heavily banked with glacial deposits on the east, south and west, that all rock is obscured by them for a distance of at least two miles in these directions, and commonly for more. The surface is everywhere strewn with loose irregular blocks of Potsdam sandstone. These accumulations may be morainic in origin, as suggested by Mr. Baldwin,* but no opportunity was afforded for closely investigating them.

Altona.

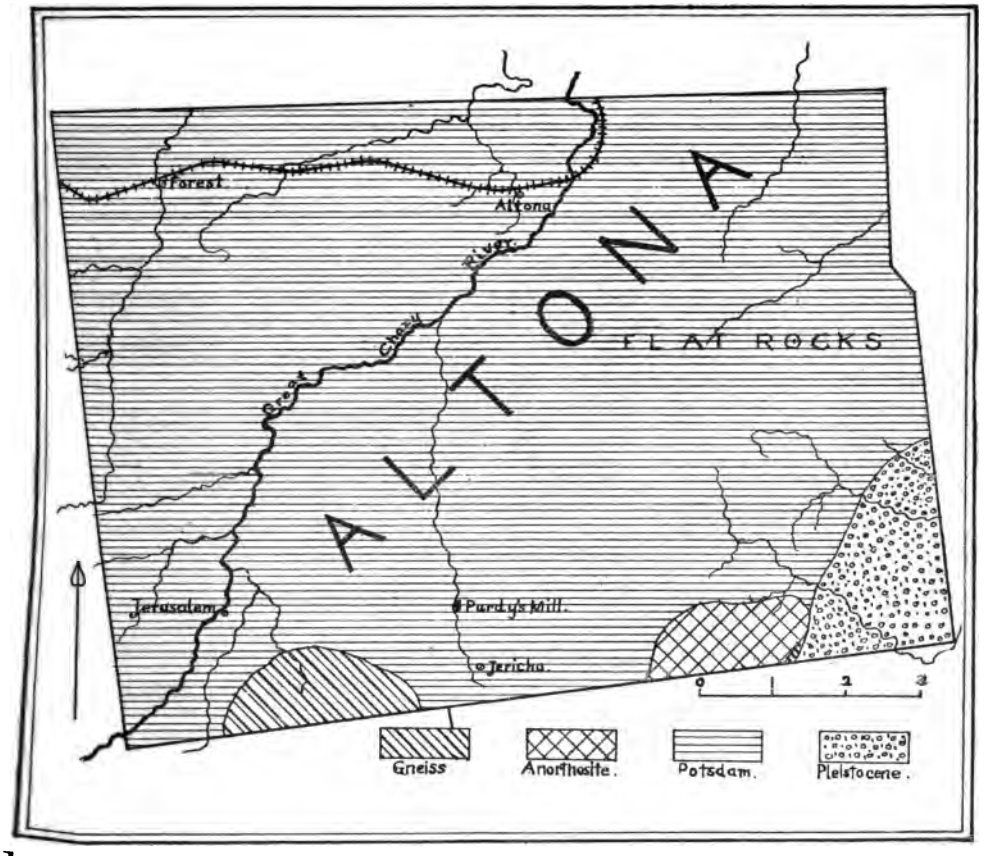
Series I. Gneiss of the ordinary microperthitic variety is exposed on the eastern side of Rand hill. Its contact with the anorthosite is shown along the turnpike (old military road) and exhibits a transition zone, a few feet in width, of a rock of intermediate mineralogic constitution. This transition rock has cataclastic structure and shows a dike-like dark band which proves to be a sheared strip, consisting of a finely granular aggregate of quartz, microperthitic orthoclase, augite, garnet, and a little plagioclase. The garnet is certainly secondary, and much of the rock has undergone recrystallization.

* American Geologist, Vol. XIII., p. 181.

The north end of the Dannemora mountain gneissic ridge projects into the southwestern part of the township, the rock being the pyroxenic gneiss usual on that ridge.

Series III. Anorthosite forms the main part of Rand hill here, as in Beekmantown. Excellent exposures may be seen along the turnpike and thence southward up the hill. The surface rock is fresher than in Beekmantown, probably due to the more energetic action of the ice-sheet on the northern slopes of the hill.

As here shown, the rock is less completely granulated than the Keeseville rock, in much of which no large fragments remain. Here none of it has

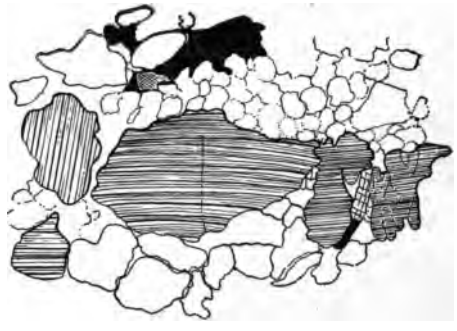


undergone complete granulation and much of it is quite coarse, so that the large labradorites, instead of the granular portions, give the main color to the rock.

Garnet is very abundant, much more so than in the Keeseville rock, so that frequently the granular matrix which surrounds the labradorite individuals has a very pronounced dark red tinge. Some portions of the rock consist entirely of garnet and labradorite. Generally, however, augite and magnetite are also present and hornblende is common. Hypersthene has

not been observed here, nor in any of the anorthosite in the county. As was to be expected from the less complete granulation, but little of the rock is foliated, the basic minerals occurring in clumps rather than in streaks.

A short distance up the hill from the turnpike, a well foliated gabbro outcrops. Owing to the tangle of brush and the thin soil covering, its extent could not be determined, but it is not great. It is less basic than the ophitic gabbros, and lacks that structure; neither have the uncrushed labradorites the abundant inclusions which characterize those of the ophitic gabbro. Besides the labradorite the rock contains much garnet and magnetite, considerable apatite, and what was probably augite now wholly passed into chlorite. Granulation is not complete. The labradorite crystals which have partially escaped this process, show beautiful polysynthetic twinning, and exhibit most notably effects of the dynamic action other than the granulation. Not only are they broken and the fragments displaced, but nearly all are bent, the bending being most clearly brought out by means of the oft-repeated twinning, as shown in the accompanying figure drawn with the camera lucida.



Broken and bent labradorite crystal from gabbro on Rand hill, Altona. The surrounding granular material is almost wholly labradorite.

Series IV. With the exception of the small areas just noted, the Potsdam sandstone is the surface rock throughout the township. Moreover, here is by far the most impressive display of this rock to be seen in the county, if not in the state. Extending north from Rand hill is a plateau of nearly horizontal Potsdam sandstone, running up to heights of 1,100, 1,200, and even 1,500 feet, and stretching away northward with an average fall in level of from seventy-five to one hundred feet per mile. For the most part it is very bare of debris, and on the steeper slopes the naked ledges of stone rise in a series of gigantic steps, as if they had been swept bare of debris by powerful currents. The district goes under the name of the "Flat rocks." It is rather deeply incised by the Great Chazy river but otherwise is not deeply dissected by erosion, appearing as a base level of tolerably recent elevation. Rand hill is a monadnock rising above this level.

It is very difficult to get any trustworthy conception of the thickness of the Potsdam as here exposed. The rock lies in a series of slight north and south folds, with such a slight dip, that it is no easy matter to determine the amount of pitch. The pitch is quite certainly to the north, and somewhat in excess of the fall of the surface in the same direction. The floor on which the rock was laid down also falls to the north, and at a greater rate than the dip of the rock.

Heavy basal conglomerates, such as those in Ellenburgh, make but little show in Altona, very possibly because of the lack of exposures in the vicinity of the crystallines, though this can not be the whole reason. Several outcrops of small extent, but occurring within a few yards of anorthosite or gneiss, are found on Rand hill, and are all of red, feldspathic, easily degraded type, with no sign of conglomerates. Away from the crystallines the rock presents its usual variations in color, size of grain, and degree of induration.

Series V. The most impressive display of dikes to be seen in the county is exhibited along the turnpike where it passes over the northeastern edge of Rand hill. The anorthosite here is seamed with dikes, some of which are very large and complex, branching repeatedly and covering considerable territory. These vary so much from place to place that measurements five yards apart would give wholly different results, but the complexity is well illustrated by the following careful measurement of a portion of Dike No. 8, made along the surface in a north and south direction. Commencing at the south is

1.	Anorthosite,		
2.	Diabase,	8 ft. 1 in.	
3.	Anorthosite,	11 " 9 "	
4.	Diabase,	0 " 9 "	
5.	Anorthosite,	16 " 2 "	
6.	Diabase,	23 " 8 "	enclosing three small horses of anorthosite.
7.	Anorthosite,	91 " 4 "	
8.	Diabase,	1 " 10 "	
9.	Anorthosite,	2 " 0 "	
10.	Diabase,	1 " 7 "	
11.	Anorthosite,	15 " 0 "	
12.	Diabase,	4 " 0 "	
13.	Anorthosite,		

The sub-divisions of this dike bear in all directions, re-uniting and forking again, so that several of the anorthosite members of the section represent enormous horses in the diabase.

Fourteen dikes have been found here within an area of less than a square mile, and if all the branches were counted separately this number would be trebled. The heavy second-growth on Rand hill undoubtedly conceals many more. The only two of these dikes that call for any especial mention are the two bostonites.* No. 7 is of the red, aphanitic type, with numerous small porphyritic orthoclases showing. It contains a little magnetite and chlorite, and the flow structure of the ground-mass is well marked. No. 9 represents the other extreme of these rocks. It is coarser, the whole appearing holocrystalline to the eye. It is much darker in shade, due to a large biotite content. Both orthoclase and biotite occur in two generations, the orthoclase phenocrysts reaching a length of over one centimeter. The ground-mass is quite coarse, and contains apatite and augite in addition to the orthoclase and biotite. Quartz has not been recognized; if present it is only sparingly so. This is the only dike of this type so far noted in the region which has phenocrysts of a ferro-magnesian mineral, and the great abundance of the biotite in this dike is quite unusual.

Chazy.

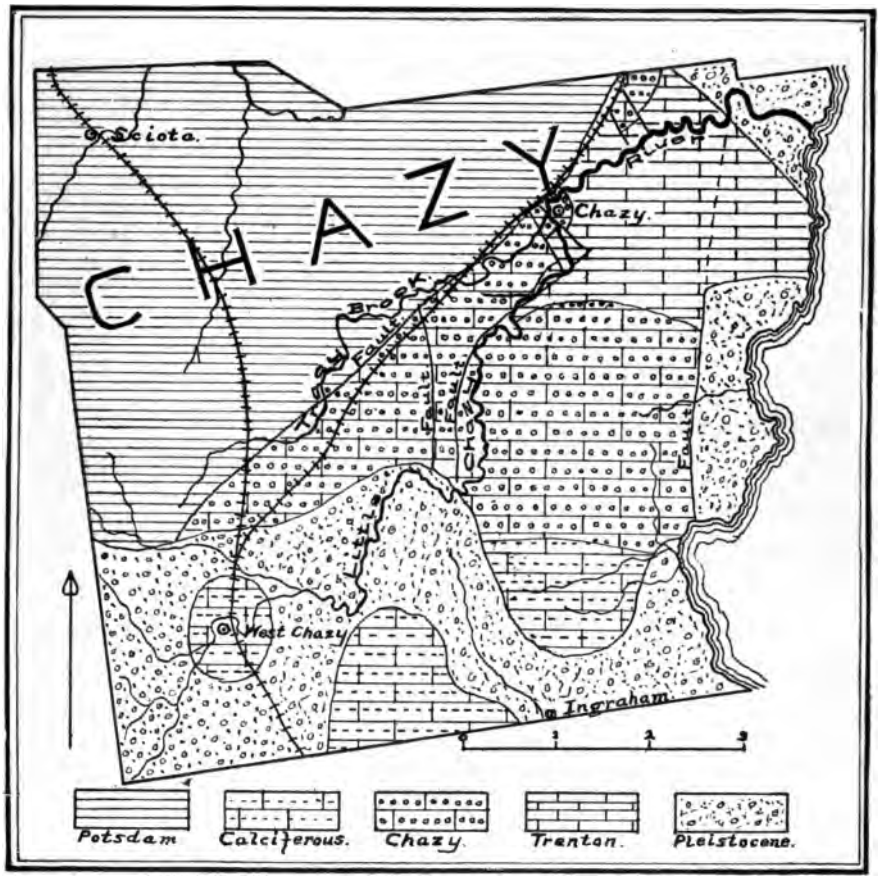
No Pre-Cambrian rocks appear in Chazy township.

Series IV. Potsdam sandstone. The Potsdam occupies the northwestern half of the township. That on the extreme west belongs to the high plain and pertains to the basal part of the formation. That on the low grounds, on the contrary, is toward the summit, the passage beds to the Calciferous appearing just over the border in Champlain township. A great fault separates the high level from the lower Potsdam, and another great fault lies between the Potsdam and the Ordovician limestones to the east of it. Most of the rock is of the ordinary character, and calls for no comment. A curious black layer, several feet thick, is exposed in a railroad cut just north of Chazy depot. While mainly a quartz rock, occasional grains of orthoclase, microcline, plagioclase, hornblende and magnetite occur, and large zircon grains are a feature. The quartz is full of minute black inclusions, and there is also a black cement of uncertain nature to which the color of the rock is due.

* Trachytes would be a better term as that is what the rock is, and no useful purpose is served by the use of the other so far as the writer can see. It is used here merely to make the nomenclature conform to that already in use in the region.

Calciferous sandrock. This formation, which is so widespread in Beekmantown, just to the south, makes but little display in Chazy, appearing only in the extreme south, where the upper beds are shown, soon to be followed toward the north by the Chazy. The exposures are poor and possess little interest.

Chazy limestone. Here is the type locality of the Chazy, and nearly the whole of the formation is exceedingly well shown. In the near vicinity of



Chazy village it has been carefully sectioned and mapped by Brainard and Seely. For convenience of reference their section is here reproduced.*

MEASUREMENTS AT CHAZY IN ASCENDING ORDER.

Group A.

1. Iron-grey, fine grained dolomitic limestone, in beds one or two feet in thickness, weathering drab with fine yellowish streaks at right angles to plane of bedding, containing *Orthis costalis* and crinoidal fragments, ... 110 ft.

*American Geologist, November, 1888, p. 324.

2. Tolerably fine limestone, filled with fragments of crinoids, containing *Orthis* and *Strophomena*, ... 20 ft.
3. Measures concealed, ... 40 "
4. Impure limestone, filled at bottom with *Orthis*, thin-bedded when long exposed to weather, the upper six feet abounding in crinoidal fragments, ... 30 "
5. Fine-grained, massive limestone containing *Scalites angulatus*, *Raphistoma* and fragments of trilobites, ... 25 "
6. Impure limestone abounding in *Orthis*, ... 10 "
7. Measures concealed, ... 25 "
8. Massive grey limestone, largely made up of crinoidal remains, having red spots in a stratum about ten feet from the top; abounding with gasteropods near the middle, ... 50 "

310 ft.

Group B.

1. Thick-bedded, nodular, dark-colored limestone, containing *Maclurea magna*, ... 50 ft.
2. Massive, pure limestone, grey, fine-grained, often oölitic, abounding in crinoidal remains and *Stenopora fibrosa*, ... 20 "
3. Massive, bluish-black, tolerably pure, nodular limestone, containing *Maclurea magna* and masses of black chert, . . . 45 "
4. Similar to No. 3, but containing in addition to *Maclurea*, various species of *Orthoceras* and large masses of *Stromatocerium*, . . 90 "
5. Less massive limestones, quite impure, and often disintegrating into nodules as though shaly, ... 60 "

265 ft.

Group C.

1. Dark, iron-grey dolomite, weathering yellowish, ... 1 ft.
2. Blue, compact, fine-grained, pure limestone, containing fine lines of calcite, ... 6 "
3. Dove-colored, compact, brittle, perfectly pure limestone, containing small nodules of calcite, ... 5 "
4. Iron-grey dolomite, ... 3½ "
5. Like No. 3, only containing larger calcite nodules, ... 4½ "
6. Dark-grey, fine grained, compact limestone, somewhat impure, having a mottled aspect when weathered, containing undetermined species of *Murchisonia* and *Orthoceras*, ... 2 "

7. Iron-grey dolomite,	1 ft.
8. Blackish, impure limestone, abounding in *Rhynchonella plena*,	36½"
9. Grey, massive, coarsely granular limestone, mostly made up of crinoidal fragments, which are sometimes red, containing *Rhynchonella*,	26½"
10. Same as No. 8,	32 "
11. Measures concealed,	7 "
12. Tough, impure dolomite,	8 "
13. Measures concealed,	24 "
	157 ft.
Total thickness of A, B and C	732 ft.

In the southern part of the township the lower division of the Chazy is widely exposed, especially toward the west, but it is much disturbed there, and no section has been seen as good as that quoted. Running due south from Chazy village, and lying just to the east of the territory included in their map, is a long section of slight dip, extending unbroken from the Calciferous up into the basal Trenton, though much of the upper and lower divisions of the Chazy are not well exposed. It is the only section in the county, except the one on Valcour Island, which shows the entire Chazy, but it is not well adapted for a determination of the thickness on account of the slight dip.

Some layers of the Chazy were formerly quarried in the township for building stone, but the industry has lapsed, probably because of the better quality of stone obtainable from Isle la Motte.

Black River limestone. Nowhere else in the county has this rock been found well exposed, but it is admirably shown around Chazy village, and is quarried and burned for lime on a large scale. It is a compact, ringing, massive black limestone, much of it with conchoidal fracture, and has a thickness of thirty feet. It is quite fossiliferous in some layers. A bed twenty feet from the base contains a large *Maclurea* and masses of *Stromatocerium*, much like the Chazy forms, so that when this layer alone is exposed, it is no easy matter to distinguish the two. *Columnaria* is confined to one or two layers just beneath the *Maclurea* bed. Beneath the beds are rather barren, but hold *Asaphus gigas* and lamellibranchs identical with Trenton forms. At the base is a *Leperditia* layer, and the whole rests on a massive, brittle, dove-colored limestone, with conchoidal fracture, which forms the summit of

the Chazy, and is missing from Brainard and Seely's section. The rock is very like No. 3 of Division C, of that section.

Trenton limestone. North and east from Chazy village, the lower portion of the Trenton is found exposed, a thickness of about 150 feet being shown. The best section is that in the Little Chazy river, just east of the village, where the dip is high, so that within a short interval, a considerable thickness of the rock is exposed. Alternating beds of black, rather slaty limestone, and more crystalline beds of lighter color, which are full of brachiopods, make up the section. They are in all respects similar to the lower beds on Crab island and in Plattsburgh, but here in Chazy is the only locality found in the county where the Black river and Chazy limestones may be seen in place below them.

Faults. Owing to the better and more frequent exposures, the faults which have dislocated the Palaeozoic rocks are more readily worked out in detail in Chazy than elsewhere in the county. They have already been discussed by the writer, in so far as the stage of the work would permit.* The past season's work in company with Messrs. Van Ingen and White corrected inaccuracies in two instances, and later on some other errors were found.

The most conspicuous and important break shown in the vicinity, is the great fault running across the township from southwest to northeast, and on into Champlain township. It will be called the Tracy brook fault, as the entire course of that stream lies along the fault line. Along its course through Chazy the entire Calciferous is blotted out, the various members of the Chazy and even of the Black river being brought down against the Potsdam. The entire throw is not far from 2,000 feet.

The downthrow block on the east of this fault is much shattered, and consists of a series of small blocks caused by cross faults. The dip is steep, ten degrees or more, and the amount of throw is ordinarily to be determined with ease by the surface shift of the Black river limestone, which forms the most convenient horizon for this purpose. Seven of these cross faults have been identified in a distance of three miles, and doubtless others will be disclosed, as detailed mapping is extended southward. This shattered zone is terminated eastward by another fault, which closely follows the course of the Little Chazy river, and may therefore be called the Little Chazy fault. But to the north and south it passes into drift-covered territory, beyond which it can not be traced. East of this fault is the long continuous section

* Bulletin Geological Society of America, Vol. VI., pp. 285-296.

of the entire Chazy, followed by the Black river and Trenton, which has already been noted. The structure is that of a low anticlinal with northerly pitch.

Still farther east, the Chazy beds are cut off abruptly by an apparent fault at right angles to the strike. No rock shows to the eastward but there is an abrupt fall in altitude of from sixty to eighty feet. This probably represents the northward prolongation of the Beekmantown fault, but has not yet been demonstrated as its equivalent.

Series V. No dikes have been found in the township.

Series VI. Besides the long esker already mentioned, nothing worthy of special description has been noted. The Champlain clays are found everywhere except on the extreme west.

Champlain.

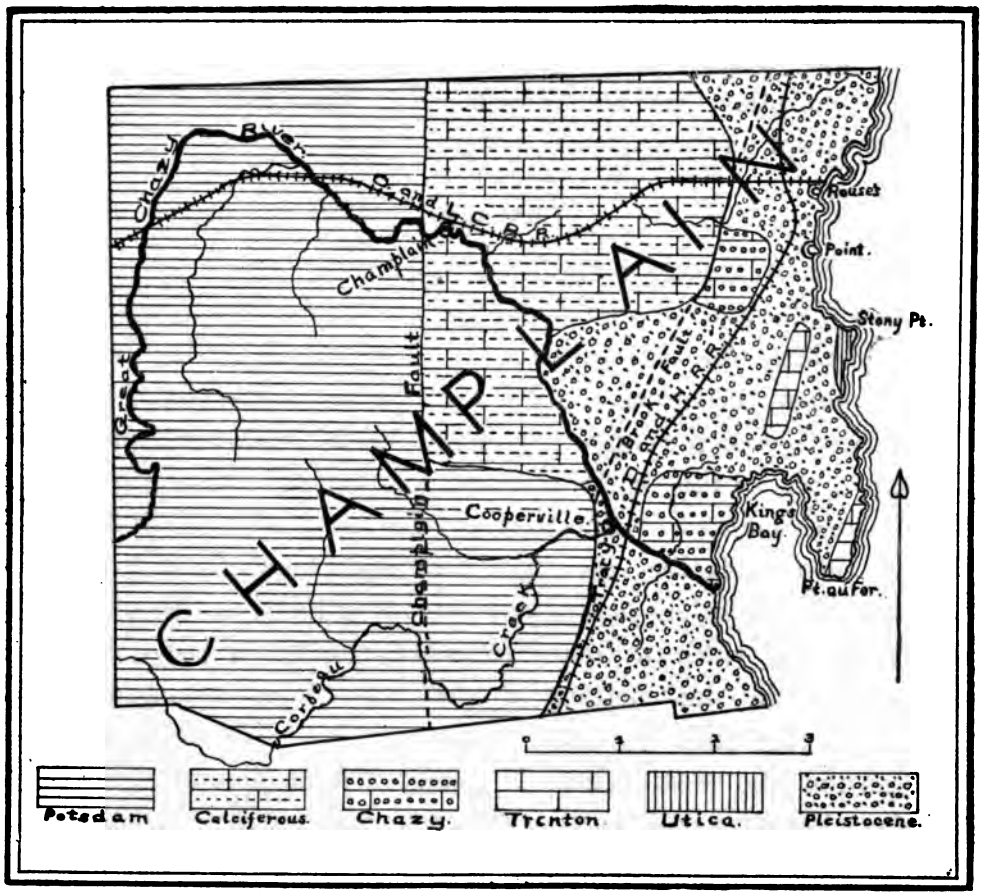
No pre-Cambrian rocks occur in Champlain.

Series IV. Potsdam sandstone. The Potsdam extends into Champlain from Chazy along the west side of the Tracy brook fault. It is exposed quite continuously along the fault line as far as Cooperville. From that point northward, dolomites appear interstratified with the sandstone, marking the passage beds to the Calciferous, and followed by the heavy grey dolomites of the Calciferous itself about a mile north of Cooperville. These continue to the Canada line, the whole with slight northerly dip.

This strip of Potsdam and Calciferous along the west side of the Tracy brook fault, has a width of from two to three miles, and is adjoined on the west by territory in which nothing but Potsdam is found clear to the Canada line, the dip being slightly to the north, as before. Not even the passage beds are seen on the west. There is clearly a fault here running the full length of the township in a nearly north and south direction, and throwing to the east. The amount of throw is purely conjectural as the horizon in the Potsdam on the west side is not known, but it has an undoubted minimum value of 250 to 300 feet. The name "Champlain fault," is suggested for it. Continued to the south into Chazy with the same trend, it would connect with the Tracy brook fault near Chazy village, the junction of the two furnishing an adequate explanation for the prominent ridge of Potsdam with abnormal dips which lies west of the Tracy brook fault north of Chazy village.

Calciferous sandrock. The Calciferous exposures in Champlain are limited to the zone between the Champlain and Tracy brook faults. As these

diverge somewhat, the width of outcrop widens northward. In this zone meagre exposures are not infrequent, but do not suffice for the construction of a section. It seems, however, that only the lower division of the formation is represented. The rock is mainly a hard, massive, grey or iron-grey dolomite, but is often very sandy, and in some layers the sand predominates, and the color is lighter. The sand is mainly coarse, and often gives a pseudo-oölitic appearance to the rock. One mile and a half west of Rouse's Point, a



layer of coarse breccia is exposed, the ordinary grey dolomite containing numerous, rather angular pieces of finer grained, more sandy dolomite, of varying size up to four or five inches in length. These pebbles, if they may be so called, are clearly derived from the formation itself, being precisely like layers which occur just beneath the breccia at that point.

Chazy limestone. A portion of the Chazy is well exposed in the district from Cooperville eastward to King's bay. Nearly the entire *Maclurea* division and much of the lower division are well shown and very fossiliferous.

The average dip is ten degrees to the east, while the Potsdam, less than a mile to the westward, has a slight northerly dip, the Tracy brook fault lying between. What is known as the King's bay quarry, is here in the *Maclurea* beds, and formerly considerable stone was taken out here.

Three miles further north, and about two miles southwest of Rouse's Point, another ridge of Chazy limestone protrudes above the surface, and has been quarried somewhat. Only a few feet in thickness of the *Maclurea* beds are seen here. They have the same easterly dip as at King's bay, though steeper, while on the west are nearly horizontal beds of the lower Calciferous, marking the further extension of the Tracy brook fault.

Trenton limestone. The road south from Rouse's Point runs for two miles just east of a low rock ridge, covered only skin deep by soil. A small opening in the rock, about two miles south of the Point, discloses Black river limestone, striking with the ridge, and therefore probably forming the whole of it. The dip is in the same direction as is that of the Chazy, a mile to the westward, so that both probably lie in the same fault block. This is the only exposure of undoubted Trenton (inclusive of Black river) in the township known to the writer. Just to the east, and occupying the larger part of the peninsula north of King's bay, is a considerable marsh which marks a fault line, beyond which are exposures along the lake shore at Stony Point and Point au Fer. On Stony Point is the Utica slate, as already described. At Point au Fer is a rocky cliff, extending several rods along shore, and exposing from fifty to one hundred feet of rock, the lower portion consisting of dark blue, somewhat slaty limestone, much jointed and with the cracks commonly filled with calcite; while the upper part is well laminated and quite argillaceous, splitting into thin, even slabs, and weathering to a light color. No fossils were found here, and the stratigraphic position of the beds is doubtful in so far that it is uncertain whether they belong below or above the Utica horizon. They are certainly not older than the Trenton, and are provisionally mapped as of that age.